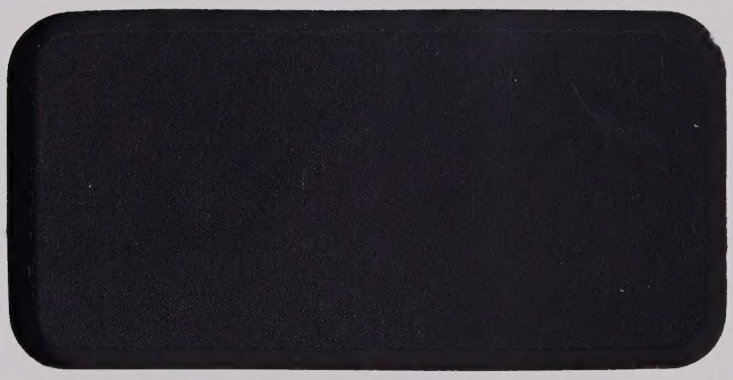
Gould 400 Series
Digital Storage Oscilloscopes
Operators Manual

GOULD



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Digital Storage Oscilloscopes
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(Gould Electronics Ltd)

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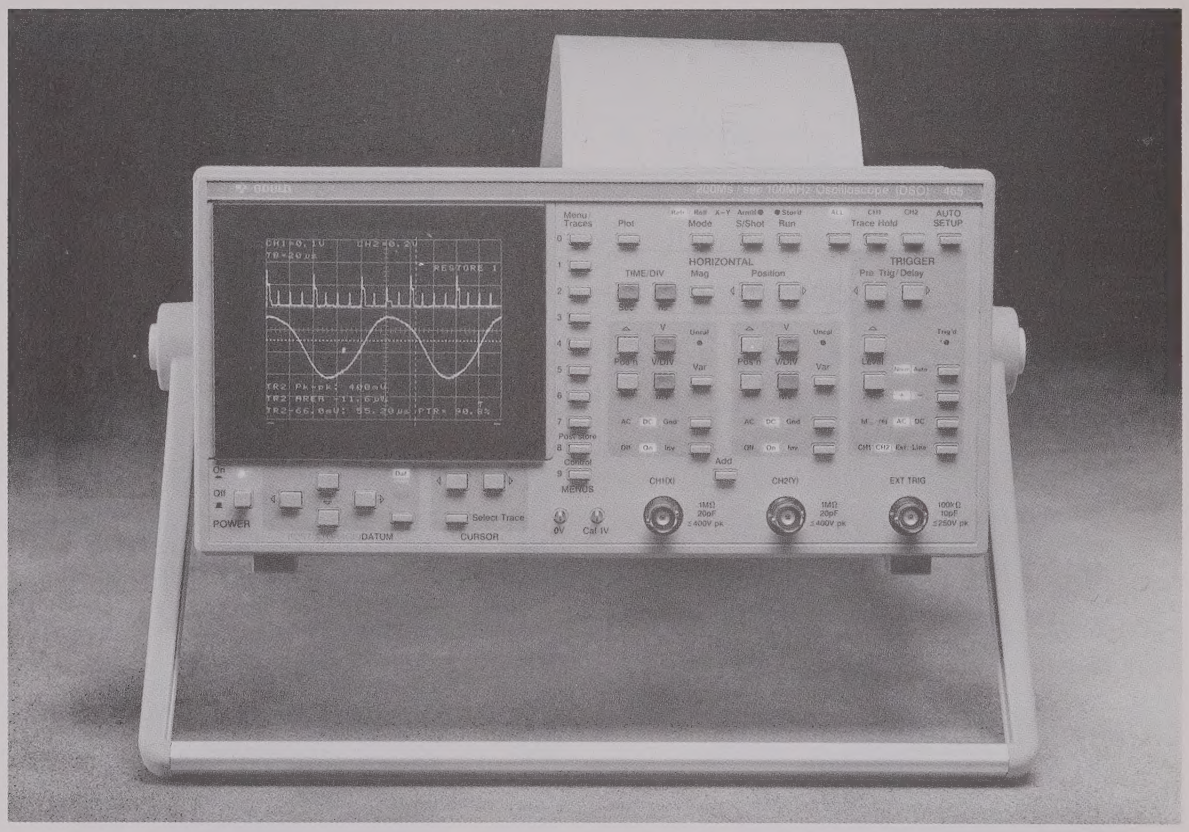
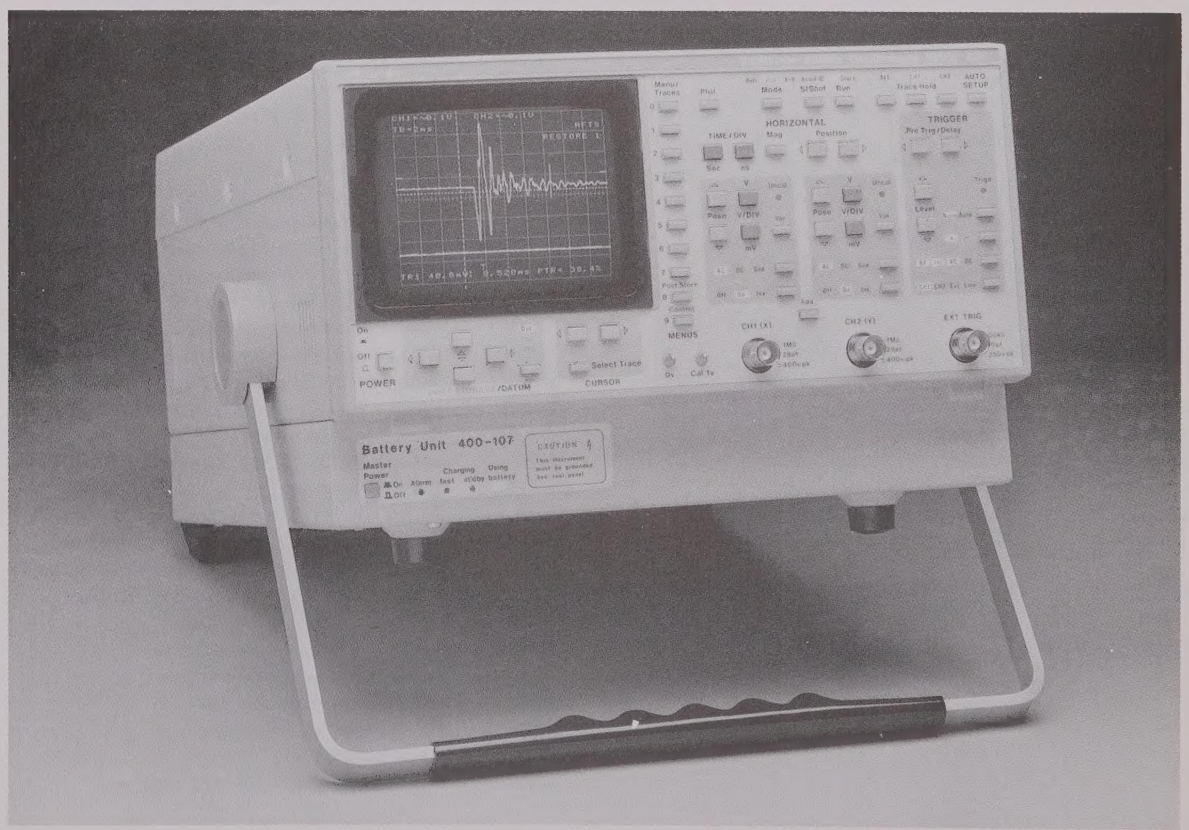

HORIZONTAL
TRIGGER
TIME/DIV
Position
Mag
Menus/ Traces
Plot
Mode
S/Shot
Run
Trace Hold
AUTO SETUP
Pre Trig/Delay
CH1(X)
CH2(Y)
EXT TRIG
MENUS
POWER
DATUM
CURSOR
Select Trace
0V
Cal 1V


Battery Unit 400-107
Master Power
Charging
Using battery
HORIZONTAL
TRIGGER
TIME/DIV
Position
Mag
Menus/ Traces
Plot
Mode
S/Shot
Run
Trace Hold
AUTO SETUP
Pre Trig/Delay
CH1 (X)
CH2 (Y)
EXT TRIG
MENUS
POWER
DATUM
CURSOR
Select Trace
0V
Cal 1V

Introduction

The Gould 400 series instruments are Digital Storage Oscilloscopes (DSOs). They include all the features expected of advanced modern oscilloscopes designed for the professional engineer, whilst retaining the user-friendliness essential for those learning to use such instruments for the first time.

400 range instruments are available in three basic bandwidths: 20MHz, 50MHz and 100MHz. All versions can be fitted with a battery unit which provides the instrument with a fully automatic built in Nickel Cadmium battery and charger which allows uninterrupted operation of the DSO in the event of an AC supply failure and complete operation independent of an AC supply.

Throughout this manual, reference to the instrument means all versions unless specified otherwise.

Obtaining a trace is especially simple - just connect the signal and press the AUTO SETUP button and the DSO does the rest. Having obtained a trace, readily accessible datum lines and a cursor make it easy to take automatic timing and voltage measurements directly form the display. On the 420, 450 and 465 models, the waveform processing function increases the power of the cursor measurements in terms of both capture and post storage analysis measurement functions.

The innovative use of ergonomically designed pressure sensitive push button controls provides a combination of precision and flexibility for ease of operation.

More advanced features of the 400 series include a comprehensive range of menu-controlled functions. For example, the Display and Trigger menu operates features such as the trigger delay and pre-trigger functions. The pre-trigger display function allows the signal *prior* to the trigger point to be captured and displayed.

Traces can be stored for future use and recalled to the display via the Save Trace and Recall Memory menus respectively. With the built in battery back-up facility, these will be retained even when the instrument is switched off.

In addition to the above features, the 420, 450 and 465 instruments have a battery backed Real Time Clock and can be fitted with an internal 4 color plotter. This provides a simple and convenient method of obtaining permanent hard copy plots of the screen display. The plots will contain the date and time of acquisition together with the date and time of plotting.

The 450 has all the features of the 420 and has a signal bandwidth of 50MHz together with an extra timebase range of 50ns/div.

The 465 has all the features of the 450 but with an increased bandwidth of 100MHz together with an extra transient capture range of 250ns/div and and extra ETS range of 25ns/div, sampling at 200Ms/s

The 400 series can be fitted with full GPIB and RS423 remote control interfaces complying with IEEE 488.2 and SCPI 1990.0

The features and options of each instrument are summarized in the table below. Note that, except on the 465, the IEEE and the Battery unit are mutually exclusive options.

Bracketed numbers in the text refer to the controls shown on the front panel picture in Appendix 6.

400 Series Features and Options

	Bandwidth			Max Sample rate		Data	Waveform	RTC	Internal	Battery	GPIB	Tube
	20MHz	50MHz	100MHz	100Ms/s	200Ms/s	Transfer	Processing		Plotter	Unit	Interface	Shield
405	✓			✓								
400	✓			✓		✓			Op	Op*	Op*	Op
420	✓			✓		✓	✓	✓	Op	Op*	Op*	Op
450		✓		✓		✓	✓	✓	Op	Op*	Op*	✓
465			✓	✓	✓	✓	✓	✓	Op	Op	Op	✓

Key:
✓ Basic instrument feature
Op Option
* Mutually exclusive
Blank Not possible

1.1 Safety, Environmental and Power Requirements

1.1.1 International Safety Warning
(as required for I.E.C. 348 Cat I)

This instrument has been designed and tested in accordance with IEC publication 348, and has been supplied in a safe condition. This manual contains information and warnings which must be observed to keep the instrument in a safe condition. The instrument should not be switched on if it is damaged and it should not be used under wet conditions.

For the correct and safe use of this instrument it is essential that both operating and service personnel follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

Whenever it is likely that safety-protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation. Qualified maintenance or repair personnel should be informed. Safety protection is likely to be impaired if, for, example the instrument shows visible damage or fails to perform the intended measurements correctly.

1.1.2 Grounding

THE INSTRUMENT MUST BE GROUNDED

AC

The instrument must be operated with a protective ground connected via the yellow/green conductor of the supply cable. This is connected to the instrument before the line and neutral connections when the supply plug is inserted into the the socket on the back of the instrument. If the final connection to the supply is made elsewhere, ensure that the ground connection is made before line and neutral.

DC

If the unit is disconnected from the AC supply, and powered from an isolated DC source or the internal battery unit, the unit will not be grounded. Independent provision MUST be made to maintain the case at a safe potential by grounding the safety ground terminal in the DSO rear panel. The safety ground terminal is electrically connected to the instrument case, to the ground of the input signals (outer of the BNC connectors), and also internally to the negative side of the DC supply.

WARNING: Any interruption of the protective ground conductor inside or outside the instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.

Signal connections to the instrument should be connected after the ground connection is made and disconnected before the ground connection is removed, i.e the supply lead must be connected whenever signal leads are connected.

WARNING: Even low voltage inputs may carry high voltage fast transients (spikes) which could damage the input and make the instrument unsafe. For this reason it is not safe to make direct connections to an AC line supply.

1.1.3 Live Parts

The instrument must not be operated with covers removed. The covers protect the user from live parts and they should be removed only by suitably qualified personnel for maintenance and repair purposes.

WARNING: Removing the covers may expose voltages in excess of 8000V at the side of the display tube; these may be present for up to one minute after the instrument has been disconnected from the power source.

1.1.4 Ventilation and Dust

The instrument relies on forced air cooling via a fan and ventilation slots. Adequate ventilation can usually be achieved by leaving a 75mm (3") gap around the instrument.

The instrument should not be operated in dusty environments.

If the CRT filter requires cleaning it can be easily removed by pressing in its right hand edge as shown by the moulded arrow.

1.1.5 Operating Temperatures

The instrument is designed to be operated in an environment having an ambient temperature of between 0 and 50 degrees C, (0 to 45 degrees if a battery unit is fitted) and to operate with full accuracy between 15 and 35 degrees C.

Note: *Direct sunlight, radiators and other heat sources should be taken into account when assessing the ambient temperature.*

The instrument may be subjected to temperatures between 0 and -40°C without degradation of its safety.

1.1.6 Power and Frequency Requirements

The instrument uses less than 85VA (200VA if battery unit fitted) and operates from nominal line voltages of 90V to 130V and 190V to 265V, at 45 to 440Hz. The instrument will still operate correctly even if there is a half cycle dropout in the line supply.

The instrument may be powered from a direct current supply in the range 12V to 33V. Both DC and AC power can be

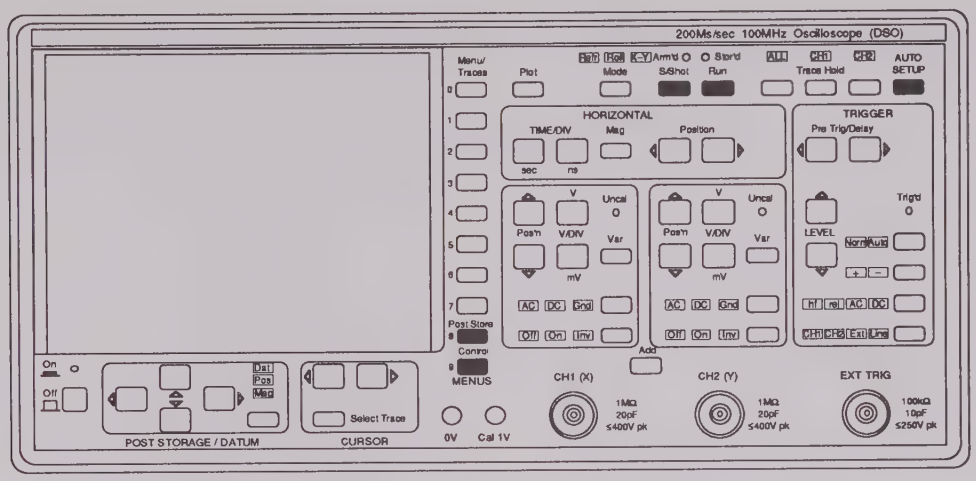


Figure 1.2a Single Function Buttons

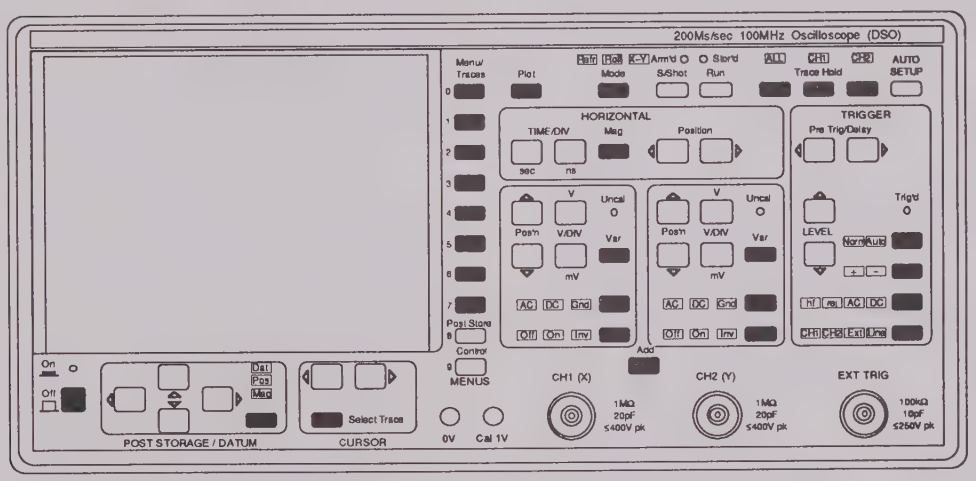


Figure 1.2b The Toggles

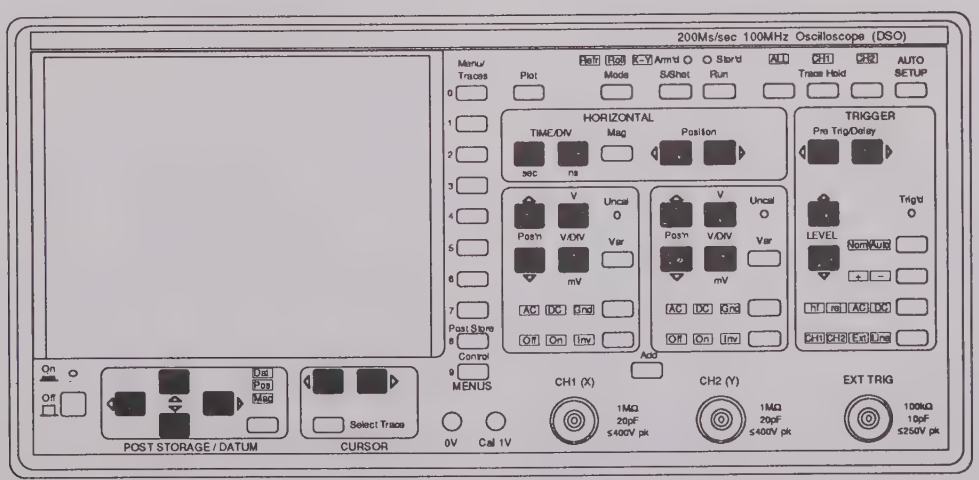


Figure 1.2c Pressure Sensitive Buttons

applied simultaneously thus providing uninterrupted operation in the event of one of the supplies failing.

Before connecting the instrument to the AC supply, ensure that the rear panel mains voltage selector is set to the appropriate voltage.

Access to the voltage selector can only be made if the mains connector is removed, and is by hinging open the panel connector from its top edge. The selector barrel can then be moved to the required setting. This same operation provides access to the mains fuse, which must be changed to suit the supply voltage as shown in table 1.1.7.

The AC power connection is via a standard IEC, CEE 22 connector, and the DC power input is via the supplied 0.25" spade connector. See appendix 4 for polarity details.

CAUTION: The negative DC terminal is connected to the safety ground terminal and the instrument case. Care should be taken to avoid ground loops when, for example, the instrument is used in a vehicle and powered by that vehicle's supply.

1.1.7 Fuse Requirements

The fuse arrangement shown in table 1.1.7 must be followed, and additionally in the UK, a 3A fuse (5A if the battery unit is fitted) should be fitted in the line supply plug.

Supply Voltage	Slow-Blow Fuse Rating IEC (UL/CSA)	Gould Part No Type No.	Suggested types Manufacturer/
		DSO	
230V	0.5A (0.6A)	457452	Beswick/TDC488, Littlefuse/239, Schurter/FSP.
115V	1A (1.2A)	457454	Beswick/TDC488, Littlefuse/239, Schurter/FSP.
12V DC	6.3A (7.5A)	460232	HRC type Beswick/S505, SIBA /70 00765 Wickman /19181.
		BATTERY UNIT	
230V	1A (1.2A)	457454	Beswick/TDC488, Littlefuse/239, Schurter/FSP.
115V	2A (2.5A)	457455	Beswick/TDC488, Littlefuse/239, Schurter/FSP.

Table 1.1.7 Fuse ratings

Note: *For different DC voltages, the DC fuse rating multiplied by the voltage used should equal 60W. e.g. at 30V a 2A fuse is required. For additional safety under extreme fault conditions, the DC fuse is a high rupture current (HRC) type. This fuse should have a 1500A break capacity.*

1.2. Using the Buttons

The front panel buttons are classified as single action, toggle or pressure sensitive.

Single action buttons have only one function: when pressed, that one function will be activated e.g. AUTO SETUP (17). See figure 1.2a.

Toggle buttons either switch something on or off e.g. Add (22), or select the next item in a sequence e.g. Off/On/Inv (21). See figure 1.2b.

Pressure sensitive buttons cause a parameter change which depends upon how hard the button is pressed. For example, a gentle press of a Pos'n (46) button will move the trace slowly. If the button is pressed harder, the trace will move more quickly. See figure 1.2c.

1.3. Start-Up Display

When switched on with the POWER button (63), the instrument will display information similar to that shown in Figure 1.3.

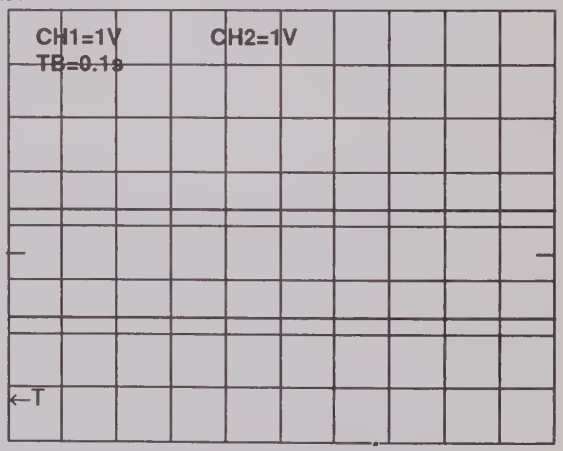


Figure 1.3 Start-Up Display

The trace is visible across the center of the screen. At the top will be the sensitivity of the two input channels and the timebase speed. If any input is inactive, information for that channel will not be displayed.

Users with no previous experience of a DSO will find that the instrument responds like a conventional Real Time Oscilloscope while it is repetitively triggered, but in the absence of further valid triggers, and with Auto Trigger switched off, it retains the last trace for continuous display.

1.4. Obtaining a Trace

Whenever the DSO is switched on, the previous control settings saved from the last power down will be used. These may not suit the current input signals. The instrument can be set to suit new signals either manually or, automatically using the Auto Setup feature.

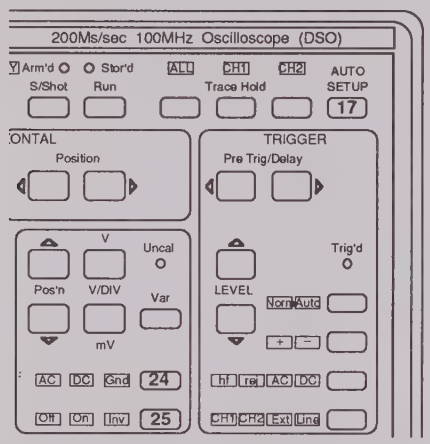


Figure 1.4 Obtaining a Trace

1.4.1. AUTO SETUP

To display an input signal, connect it via either the CH1 socket (60) or the CH2 socket (59) and press AUTO SETUP (17).

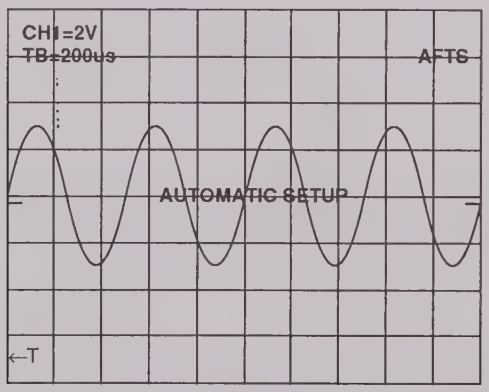


Figure 1.4.1 An AUTO SETUP Display

Assuming you've applied a repetitive signal, say 2kHz sine-wave with an amplitude of perhaps 5V peak to peak , it will almost immediately be represented on the display. An example is shown in Figure 1.4.1.

If the display is very dim or has completely disappeared see section 1.10.2.

AUTO SETUP will attempt to arrange the display so that two to five complete cycles appear, with the amplitude set so that the height of the trace is between two and five screen divisions. Also, it selects auto trigger to ensure that the screen is frequently updated and a trace will be visible.

If signals are connected to both channels, the timebase is set to suit the higher amplitude signal.

1.4.2 Manually Obtaining a Trace

This subsection describes how to obtain a trace without using **AUTO SETUP.**

You may need to consult later sections of the manual as not all of the operating features have been discussed so far.

1. Switch on the instrument.
2. Decide to which channel you are going to apply the signal (CH1 or CH2).
3. Make sure the chosen channel is active by setting the **Off/On/Inv** (21) or (25) for that channel to On.
4. Set the **AC/DC/Gnd** button (20) or (24) for the chosen channel to Gnd.
5. If necessary, turn that channel's **Uncal** light out by pressing **Var** once (19) or (23).
6. Make sure that horizontal mag is not selected. (18)
7. Adjust the **TIME/DIV** setting (32) & (33) to give a timebase of 5ms.
8. Set the display **Mode** (11) to **Refr.**
9. Set the TRIGGER **Norm/Auto** button (26) to Auto.
10. Use the **CH1/CH2/Ext/Line** button (29) to choose the source for trigger signals.
11. Set the trigger coupling with the **hf rej/AC/DC** button. (28).
12. If necessary adjust the position of the trace using the Horizontal **Position** and Vertical **Pos'n** buttons (34, 35) & (36, 37) or (38, 39).
13. Ensure that **Trace Hold** (14), (15) or (16) is not selected.
14. Select **Run** (13).
15. Apply the signal through a BNC connector to the chosen CH input socket. (59) or (60).
16. Set the **AC/DC/Gnd** button (20) or (24) for the channel to either DC or AC, as appropriate.
17. Adjust the gain of the chosen channel using the **V/DIV** buttons (36, 37) or (38, 39). For intermediate settings, set **Uncal** on by pressing the **Var** button once. (19) or (23).
18. Adjust the timebase setting using the **TIME/DIV** buttons. (32) & (33)
19. If the display is unstable, adjust the trigger **Level.** (52) & (53).

1.5 Channel Controls

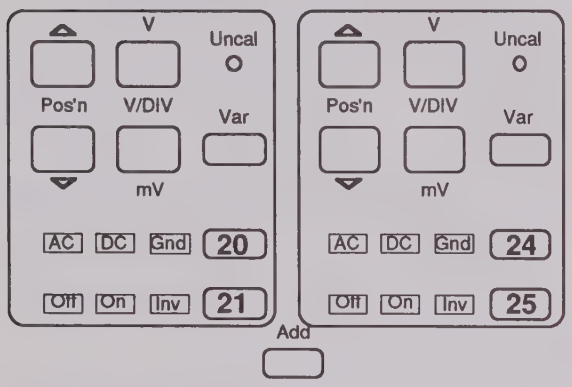


Figure 1.5 Channel Controls

1.5.1. Channel Selection (Off/On/Inv)

A channel may be switched on or off with its **Off/On/Inv** button (21) or (25). If the channel is on, its trace can be displayed in either normal or inverted mode.

Off The channel display is de-activated but the signal can still be used as a trigger source.

On The trace is a true representation of the input signal.

Inv The input signal is inverted before being displayed. If there is any DC component in the signal this will also be inverted and could cause the trace to disappear from the screen. Such an unwanted DC component can be removed by selecting AC coupling. Any vertical shift applied to the trace is not inverted. The trigger point remains at the same point on the waveform regardless of inversion.

1.5.2. Coupling (AC/DC/Gnd)

These buttons (20) & (24) control the type of coupling between the input signal and the instrument. DC is the most generally applicable, and AUTO SET UP will normally set this control to DC, where possible.

The input impedance is 1M ohm in parallel with a capacitance of 20 or 28pF depending on instrument type, see Appendix 2.

AC This is used to remove any DC component from input signals. Suitable input signal range (i.e. the bandwidth) is from 4Hz to 20, 50 or 100MHz depending on the instrument type.

Gnd The input signal is internally disconnected from the inputs and the amplifier grounded. A 0V reference signal is displayed.

DC The input signal is directly coupled to the instrument so all frequency components of the input signal will be displayed. The bandwidth will be from DC to the instrument limit either 20, 50 or 100MHz depending on the instrument type.

1.6 Horizontal Adjustments

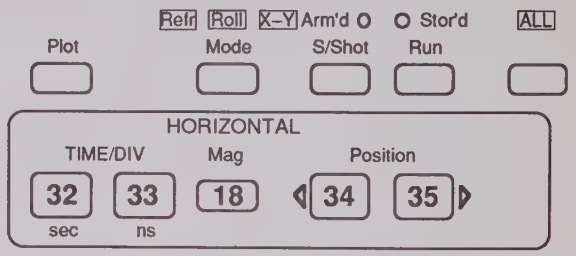


Figure 1.6 Horizontal Controls

1.6.1. TIME/DIVISION

Time/Div (32) & (33) These buttons control the sweep rate of the trace. The timebase can be varied from 50s/div to 25, 50 or 100ns/div in a 1, 2, 5 sequence of values depending on instrument type. The button marked "ns" decreases the time/div, the button marked "sec" increases the time/div.

With a timebase of say 0.2s, each horizontal screen division represents 0.2s worth of signal. The timebase is shown near the top of the display - e.g. TB = 0.2s.

At timebase speeds of 200ns and faster, the DSO uses Equivalent Time sampling (ETS) to build up a picture from a number of separate acquisitions by sampling the repetitive waveform at varying times relative to the trigger point, to eventually capture the entire input waveform. ETS ranges can only be used to capture repetitive signals.

1.6.2. Aliases

Assuming a 2kHz signal is applied as mentioned earlier, when the timebase is set to 0.5s/div, an interesting phenomenon may appear: an "alias".

An alias is a false image. The instrument is a digital oscilloscope and so takes frequent samples of the input signal in order to update the trace. Thus, if the signal frequency is higher than the sample frequency, one sample will be taken from a particular point on the waveform and the next sample may be taken from a point slightly further along on a subsequent cycle. It will then display the wave as being much slower than it is in reality. See Figure 1.6.2.

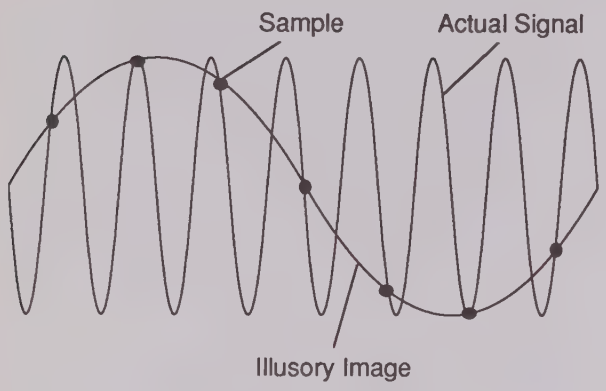


Figure 1.6.2 Alias Generation

There is a "Max/Min" glitch detection feature which can be used to detect aliases. With dot join on, this usually results in a filled-in wave envelope being seen on the screen, indicating a high frequency. See Section 3.4.

1.6.3. Position

Position (34) & (35) These buttons move all traces to the right or left.

The position of the cursor (Section 2.4.) is fixed in relation to the trace so it will move with the applied shift. With x-magnified traces (Section 1.6.4.), the cursor can be off the part of the trace displayed on the screen. To bring it back into view use the CURSOR < > buttons (44) & (45).

1.6.4. Magnification

Mag (18) Switches horizontal magnification on or off. When switched on, a x10 expansion is applied to any displayed trace, which will expand around the center of the screen. The timebase displayed is adjusted to reflect the expansion.

The instrument displays 50 dots (samples) per horizontal screen division, each plotted dot value being obtained from the 512 byte acquisition memory. At an expansion of x10, there are five acquired dots per division, the remaining dots being produced by linear interpolation.

1.7. Vertical Adjustments

Each channel has its own set of vertical controls. See Figure 1.7.

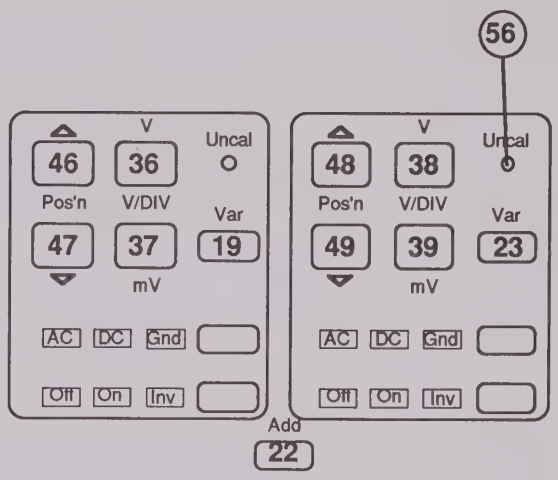


Figure 1.7 Vertical Controls

1.7.1. VOLTS/DIVISION

V/DIV (36) to (39) Adjusts the sensitivity of the instrument over discrete calibrated ranges from 2mV to 5V per screen division in 1, 2, 5 steps. With a x10 probe the ranges are 20mV to 50V per division at the probe tip. See Section 3.4.1. If the **Uncal** light is on, then these buttons vary the sensitivity continuously. See Section 1.7.3.

1.7.2. Position

Pos'n (46) to (49) These move their respective traces up and down the display.

If **Trace Hold** is on (Section 2.1.) or a S/Shot capture has been made, this control does not move the trace and the post storage **Pos** control should be used instead. See section 2.3.4.

1.7.3. Variable/Uncalibrated

Var (19) & (23) When this is set to "Uncal", the coarse setting of the attenuator remains unchanged, but a variable attenuation is applied to the input signal in the range of 1 to 0.4. Thus, with an initial setting of 1V, the actual sensitivity of the channel could be set by this control to anywhere between 1V and 2.5V per division. The **V/DIV** buttons are used to vary the uncalibrated sensitivity.

Screen display explanation:

CH1=5V	Channel 1 is set to a sensitivity of 5 Volts per screen division.
CH2>20mV	Channel 2 is uncalibrated and the attenuator is set to a sensitivity greater than 20mV per screen division.
CH1=~5V	Channel 1 is set to a sensitivity of 5 volts per screen division and is AC coupled.
CH1=–5V	Channel 1 is set to a sensitivity of 5 volts per screen division and is inverted

1.7.4. Add

Add (22) Displays the sum, or if one channel is inverted the difference, of the input signals. The original traces disappear and the resultant trace is displayed as trace 2.

1.8 Trigger Control

Trigger facilities discussed here are controllable directly from the front panel. For the more advanced menu-controlled facilities see Section 3.4.

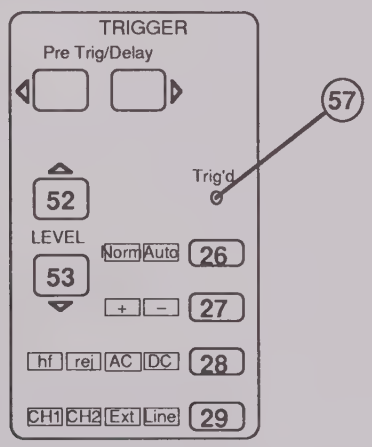


Figure 1.8 Trigger Controls

1.8.1 Selecting Source and Coupling

The lowest button in the TRIGGER section of the front panel selects the source of the trigger.

CH1/CH2/Ext/Line (29) Steps through the possible sources of trigger signals. When Ext is selected, the source is the "EXT TRIG" socket (58) in the lower right corner of the front panel.

Selecting line is meaningful only if the instrument is powered from the mains. Triggering is then from an internal pulse having a fixed phase relation to the mains voltage waveform. To change this phase relationship, use the trigger delay buttons. See Section 2.1.6.

hf rej/AC/DC (28) Steps through the available trigger coupling options; hf rej is a 15kHz low-pass filter ("high frequency reject"). All the couplings can be used with any source except Line.

Coupling	Input Frequencies
hf rej	15kHz bandwidth
AC	4Hz to 20, 50 or 100MHz
DC	DC to 20, 50 or 100MHz

Table 1.8.1. Useful Frequency Ranges of Coupling Types

1.8.2 Trigger Level

The trigger level is the threshold at which the instrument will respond to potential triggers; the trace actually has to pass through the level indicated in the appropriate direction as defined by Slope (section 1.8.4) for a trigger to be valid.

The level is indicated on the display by two bars, one on each side of the screen, and is adjusted by the level buttons (52) & (53). For an internal trigger the range is ±10 divisions and on external approximately ±3V. If the trigger signal is AC coupled, the level bars will be offset from the actual trigger position on the screen by any DC offset present.

1.8.3 Trigger Point (T)

The trigger point is indicated on the display by a "T" near the bottom of the screen underneath the trigger. An arrow next to the T indicates that the trigger point is off the screen. An arrow and a vertical line indicates that the trigger is at 0 or 100% pretrigger (the left or right hand edge of the display).

1.8.4 Trigger Slope (+/-)

A trigger is generated when the selected source signal passes through the chosen trigger level in the selected direction. This transition may be either on a rising or a falling edge. The rising edge is considered to be a positive slope and the falling edge a negative slope.

+/- (27) This button selects positive (+) or negative (-) slope triggers.

1.8.5 Trigger Mode (Norm/Auto)

The trigger system operates in either Normal or Auto mode.

In Normal mode, acquisition triggers only occur when valid triggers are present.

In Auto mode, if no valid trigger has been received for 50ms the instrument will generate its own trigger and initiate a capture. This ensures that the screen is constantly updated irrespective of the input signal. However, if valid input triggers are received at a rate of 20Hz or more, the instrument will behave as if it is in normal mode.

AUTO/NORM (26) This button selects the trigger mode in which the instrument is operating.

Trig'd (57) This LED lights up when the instrument is receiving valid trigger signals.

1.9 Trigger Delay

The amount of data which is acquired for display before or after the trigger is determined by the pretrigger or trigger delay selected, see figure 1.9b. The value of this delay is shown in the bottom right hand of the trace display.

Figure 1.9a Trigger Delay Controls

1.9.1 Pretrig This allows a section of the trace that occurred before the trigger point to be included in the display. The amount of pre-trigger visible can be set with the front panel **Pre Trig/Delay** buttons. (50) & (51). Pre-trigger can be set anywhere between 0% and 98% or 100% of screen width (depending on instrument type), in steps as small as 0.4%.

1.9.2 Delay by time With this set, the oscilloscope will acquire a trace following both the specified trigger and a specified delay. The amount of delay is shown at the bottom right of the display. Delay is controlled by the **Pre Trig/Delay** keys. (50) & (51). The size of the steps by which the delay can be incremented or decremented is controlled by the **TIME/DIV** keys, i.e. step size is 0.04 x the time/div setting. To obtain long delays on a fast timebase, it can be easier to select a slower timbase, set the delay and then reselect the original fast timebase. Once set, the delay time remains the same regardless of the selected timebase range.

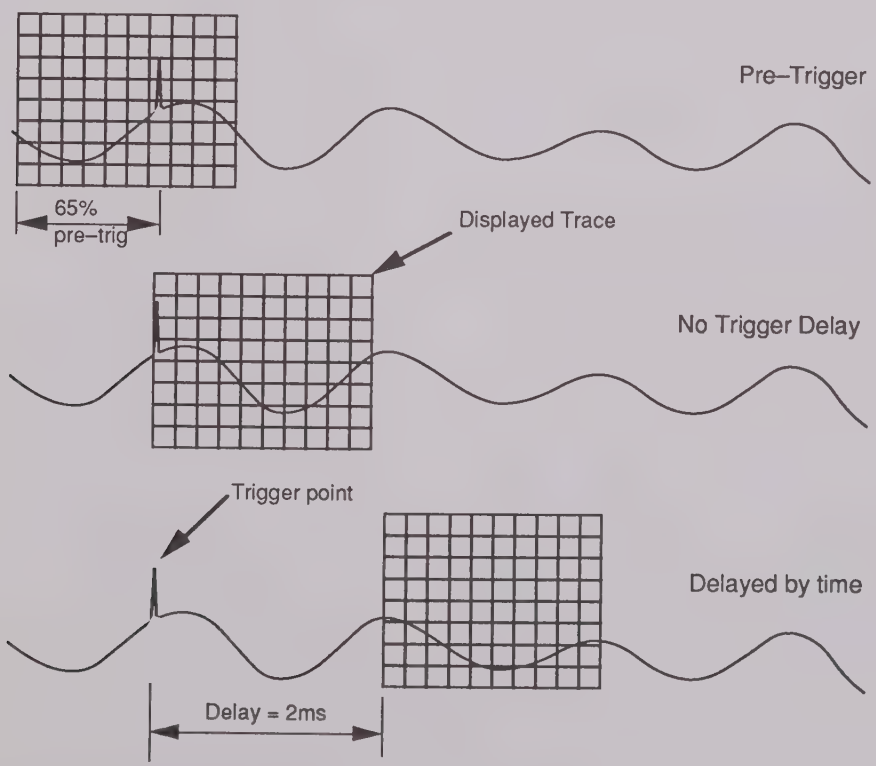


Figure 1.9b Trace Capture with Delay

1.10 Operating Hints

This section explains how to perform a system reset and gives some of the problems more commonly met in operating digital oscilloscopes, how to correct them, and a brief explanation of what was wrong. Later sections of the manual may need to be consulted as some of the operating features have not yet been discussed.

1.10.1 System Reset

Should the system memory become corrupted, the instrument could lock out the front panel operation or begin to behave erratically. Since the internal system variables are held in battery-backed memory, turning the set off and on again may not clear them. In this unlikely event a system reset may be necessary.

A system reset should only be used as a last resort as all the internal memories will be cleared erasing all reference traces, calibration details, and set-up details.

To perform a system reset, switch the instrument off. Press and hold the **Hold All** button. Keep the **Hold All** button pressed and turn the instrument on using the **Power** button. When flashing lines appear on the screen, the **Hold All** button should be released. The instrument will then perform a full calibration and select its default setup.

A system reset must be followed by a full calibration once normal operating temperature is reached.

1.10.2 Problem: Traces and Alphanumerics very dim or completely invisible.

Intensities too low

- Press the Control key (9) then numeric button **3** to select the intensity menu. Hold button **3** pressed to increase the alphanumeric brightness on the display. The traces can now be intensified using numeric button **1**.

Note: *The alphanumerics may not become visible until the numeric button 3 has been pressed several times.*

1.10.3 Problem: Trace off the top or bottom of the screen.

Too much vertical shift

- Correct with that channel's **Pos'n** buttons. (46) to (49)

Input has large DC offset

- AC couple input signal.
- Correct with **Pos'n** buttons. (46) to (49)
- Use a less sensitive range.

1.10.4 Problem: Trace not being acquired.

Instrument in single capture mode

- Press **Run** (13)

Trigger level incorrect

- Select Auto and DC trigger, then adjust the level control until the trigger level indicator bars are lined up with the center of the trace.

Trigger source on the wrong input

- Change trigger source. (CH1, CH2, Ext, Line). (29)

Trigger coupling on an unsuitable setting

- Change trigger coupling. (hf rej, AC, DC). (28)

Trace Hold on

- Release **Trace Hold.** (14), (15) or (16))

Timebase on very slow acquisition

- Adjust **TIME/DIV.** (33)

1.10.5 Problem: Trace is unstable even when triggered.

Alias

- Check for alias using Max/Min (glitch detection), and select a faster timebase range.

Noisy input

- Select **hf rej** trigger coupling if the input signal is less than 15kHz. (28)
- Adjust trigger **Level.** (52) & (53)

Trigger on Auto

- With low frequency inputs (below 20Hz), **Auto** trigger will initiate triggers overriding the input triggers. Select **Norm** trigger. (26)

1.10.6 Problem: Trace has a very flat top or bottom.

Trace captured when off screen vertically and post storage **Pos** shift has been used

- Use less sensitive **V/DIV** range when acquiring trace. (36) to (39)
- Re-position trace prior to capture.

1.10.7 Problem: Auto Setup fails.

If Auto Setup fails it is most likely that the signal connected to the instrument is unsuitable for the automatic setup system for one or more of the following reasons.

Signal not repetitive.
- Auto Setup only works on repetitive signals

Signal amplitude too small or too large.
- Instrument needs to use a different V/Div range. Use a probe with a suitable gain, i.e. x1, x10, or x100.

Signal frequency too slow or too fast.
- The signal frequency is outside the range of Auto Setup.

Signal not constant.
- Amplitude and or frequency variations during the Auto Setup routine may interfere with its correct operation.

High frequency noise on signal.
- The noise may be interpreted as a high frequency signal instead of being ignored as noise on a lower frequency signal.

1.10.8 Problem: Cursor measurements apparently wrong.

Wrong probe gain selected.
- Select correct probe gain to suit probe in use. See section 3.4.

Datum not set correctly.
- Re-position datum on trace (40) to (43).

Cursors on wrong channel trace.
- Position cursors on trace of interest (31).

1.10.9 Problem: Single Shot acquisition takes longer than expected.

Averaging or persistence modes selected.
- Turn off both averaging and persistence.

An ETS timebase is in use with infrequent triggers.
- Use the Time/div key to change to a non ETS timebase.

An ETS timebase is in use with non repetitive or non triggered signal.
- Change to a non ETS timebase.
- Adjust the trigger controls to obtain a trigger signal.

2. DSO Features

2.1 Capture Facilities

The capture facilities allow the traces to be frozen.

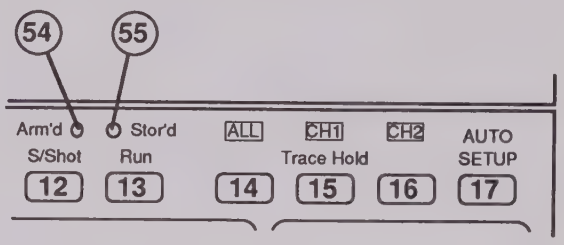


Figure 2.1 The CaptureControls

2.1.1 Trace Hold

There are two ways to freeze the display: a single-shot capture whereby a full trace is acquired then frozen (Section 2.2.2), or by pressing one of the trace hold buttons (14), (15) or (16).

Trace Hold: (14), (15) & (16) Freezes the relevant trace or traces the moment they are pressed. A second press releases the trace(s).

2.1.2 Single Shot and Run

These buttons are used to set the instrument into either a capture-and-freeze mode **(S/Shot)**, or a free running continuous capture and re-capture mode **(Run).**

S/Shot (12) Arms the instrument for a single-shot triggered acquisition. The Arm'd light will be illuminated to show that the button has been pressed.

Arm'd (54) Illuminates after the **S/Shot** button has been pressed; it will stay lit until either a valid trigger has been accepted or until the **Run** button is pressed.

Stor'd (55) Illuminates on completion of a single-shot acquisition. This is after the instrument has been Arm'd, triggered and a complete trace acquired. The light will stay on until the instrument is re-armed by pressing **S/Shot** again or **Run** is pressed.

Run (13) This button puts the instrument in continuous capture mode: the instrument will automatically re-arm itself after each capture is completed so that the display will update with each triggered sweep.

2.1.3 Acquisition Status - AFTS

These characters appear on the screen and can be used with the **Arm'd** and **Stor'd** lights to determine the status of the acquisition in progress.

A Stands for "Armed".

F Indicates that the acquisition store has been "flushed" and filled with enough pre-trigger information to be ready for a fresh trigger in pre-trigger acquisition. Until this condition is met and F displayed, triggers may be detected, as indicated by the trigger LED, but not accepted for the next acquisition.

T Stands for "Triggered" : the instrument has accepted or generated a valid trigger; acquisition has begun.

S "Stored" : acquisition is complete.

2.2 Display Modes

The following three display modes are directly selectable using the **Mode** button. (11).

2.2.1 Refreshed. The instrument will imitate the style of a conventional realtime 'scope: the trace is displayed from left to right as it is acquired.

2.2.2 Roll This mode is like a chart recorder: the display scrolls from right to left until a trace has been acquired. The scrolling effect is most noticeable on the slower timebase ranges. The rolling display is frozen by the trigger in S/Shot mode and is unaffected by trigger in Run.

2.2.3 X-Y This mode allows the CH1 socket input to control the X (horizontal) component of the trace, and the CH2 socket input to control the Y (vertical) component. It provides an X-Y display of the data captured by the timebase and trigger systems. The timebase should be set slow enough to capture the whole of the signal of interest. This mode is not available with magnified traces (**Mag**).

2.2.4 Persistence A refreshed mode in which successive acquisitions are added to the current display. The number of acquisitions or the time before clearing the display is set in the Persistence Limits Testing menu accessed from the Post Storage Master Menu. The latest acquisition is shown brighter than the persisted acquisitions.

2.3 Cursor Measurements (built in)

The instrument allows you to take direct measurements from the screen display automatically, using datum lines and a cursor.

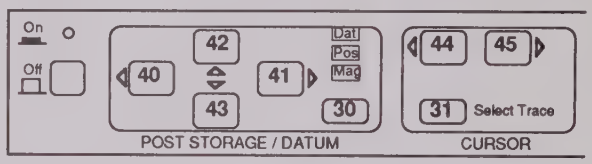


Figure 2.3 The Cursor and Datum Line Controls

2.3.1 Cursor and Datum Selection

The cursor and datum lines are switched on or off using the **Select Trace** button. (31).

Select Trace (31) Successively pressing this button places the cursor onto the displayed traces in turn, i.e. trace 1, trace 2, reference, off, trace 1 etc. If a trace is not in use, the cursor skips to the next valid selection.

2.3.2 The Cursor and Datum Lines

There are three lines, as indicated in Figure 2.3.2. Movement of them is achieved using the **DATUM** and **CURSOR** buttons as described below.

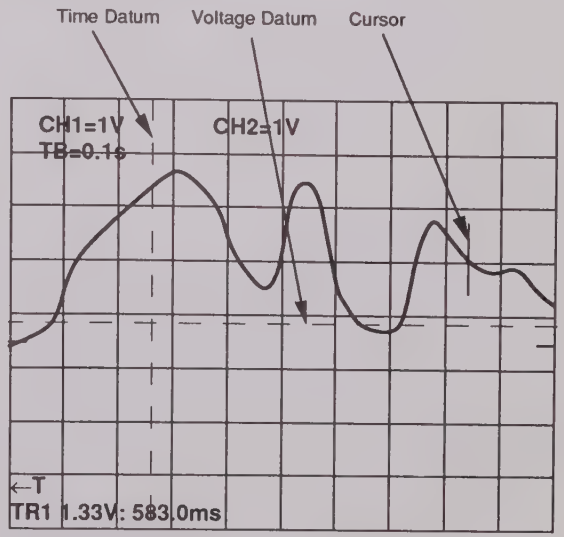


Figure 2.3.2 The Cursor and Datum Lines

Dat Selecting this option on the **Dat/Pos/Mag** button (30) allows the position of the datum lines to be controlled using the **DATUM** buttons. (40) to (43).

DATUM (40) to (43). Used for moving the two datum lines.

CURSOR (44) & (45) Moves the cursor horizontally.

2.3.3 Making Measurements

The instrument displays, at the bottom of the screen, the results of waveform measurements. The section of the trace to be measured is usually defined using the horizontal and vertical datum lines and the cursor.

The choice of points between which to make the measurements can influence the accuracy: while the measurements made will always be within design limits, placement of the cursor at the desired position is easier at those points where the slope of the waveform is at its steepest. For example, on a standard sine wave, the most accurate measurements of frequency are likely to be made if they are taken between two 0V crossing points.

For details of the DSO's waveform measurement capabilities see section 5.1

2.3.4 Post Storage Manipulation

Pos/Mag These selections on the **Dat/pos/mag** button (30) allow the DATUM buttons to control post storage position and magnitude. They can only be used with stored waveforms. Pressing menu button **1** (opposite the restore message) will cancel the effect of pos and mag on the selected trace.

Pos This option on the **Dat/Pos/Mag** button (30) allows both X and Y shift to be applied to the trace on which the cursor is placed, using the **POST STORAGE/DATUM** keys (40) to (43).

Mag The vertical magnitude of the selected trace can be varied from x4 to x0.062, using the **POST STORAGE/DATUM** keys (40) to (43). The magnification factor is displayed near the top center of the CRT.

No horizontal magnification is available using this control, but x10 magnification may be applied to all stored traces using the horizontal mag button, (See Section 1.5.4.).

2.4 Plot

2.4.1 Internal Color Plotter Operation

When the internal color plotter is fitted to the DSO, plots of the instrument's display can be sent to it by selecting internal on the Plot Menu, see section 3.12.

The internal plotter is automatically selected after a cold start if it is fitted. If required the plot output can be directed via the RS423 or GPIB port to an external plotter by selecting RS423 or GPIB on the Plot Menu, see section 3.12.

2.4.2 Pens

Only use Gould pens - part number 04101175 for a pack of 4; 1 of each color or part number 04101265 for a pack of 4 black pens.

The normal pen sequence is:

Pen No.	Color
1	Black
2	Blue
3	Green
4	Red

The pen holder is color coded with this color sequence. When pens are fitted in this order, trace 1, the border and all the alphanumerics are plotted in black, trace 2 in blue, the reference trace in green and the graticule in red.

The cursor and datum lines and their measurements are plotted in the same color as the trace to which they relate.

2.4.3 Pen Changing

Underneath the plotter lid at the front of the plotter there are two small blue buttons. The right hand button when viewed from the front of the DSO is the Pen change button, and the left hand one is the paper advance button.

CAUTION: When changing a pen, extreme care should be taken not to damage the plotter mechanism. NEVER move the pen carriage by hand.

To change a pen, ensure that the instrument is switched on and then proceed as follows:

1. Press the pen change button once. This rotates the pen carriage and moves the carriage to the right hand side of the plotter.
2. Gently press the white grooved eject lever towards the front of the instrument. The top pen will be ejected from the pen carriage and can be removed from the plotter.

3. Insert the tip of the new pen into the carriage guide hole. Gently snap the other end of the pen into place.
4. When the pen has been changed, press the left hand button - the paper advance button - and the carriage will move back to the left hand side ready for the next pen change or plot.

2.4.4 Paper selection

Only use Gould paper - Part number 04101165 for a pack of 10 rolls. Other paper types may damage the mechanism.

2.4.5 Paper Loading

CAUTION: When loading paper, extreme care should be taken not to force the plotter mechanism. NEVER pull paper through by hand, always use the paper advance button to prevent damage to the plotter mechanism.

1. With scissors, cut the end of the paper square.
2. Open the plotter cover by depressing the catch and lifting the cover until it is fully open.
3. Remove the shaft from the paper cradle and if the plotter has been used previously remove the plastic or cardboard tube from the shaft.
4. Insert the shaft through the paper roll and fit the roll into the paper cradle.
5. Feed the paper from the top of the roll as shown in figure 2.4.5 below and push it through the slot in the rear of the printer mechanism.
6. Press the paper advance button - the left hand blue button at the front of the printer assembly - until the paper reappears at the front.
6. Feed enough paper through to pass through the top cover, ensure that it is running around the mechanism smoothly and that it is straight.
7. Close the plotter cover and ensure that it latches shut.

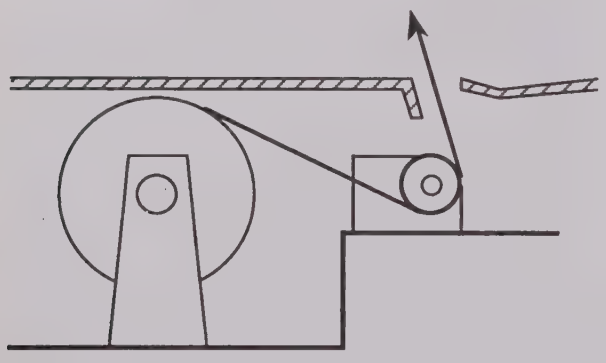


Figure 2.4.5. Paper Loading

2.4.6 Internal Plotting

When a plot is initiated, the Hold All LED lights and the message "PLOTTING - PRESS PLOT TO ABORT" appears on the screen. After about 9 seconds the Hold All LED goes out indicating that the data has been transferred to the plot buffer and that the instrument can be used again. The plotting message will remain on the screen until the plot is complete when it will disappear.

In Auto Plot Mode, the instrument is re-armed after the plot data has been transferred to the plot buffer, but the front panel controls will remain in-active during plots.

If the plot button is pressed while the plot is in progress, the plot will be aborted. Any changes to the instrument status during a plot will have no effect on the plot as the data will have been transferred and stored in the plot buffer.

2.4.7 External plots

The parameters for the plotter interface and the plot format can be set as described in section 3.7 and 3.12.

A plot of the display can be sent to an external plotter by pressing the plot button (10). The display is held while a plot is in progress.

Plots can be aborted by a second press of the plot button. If the plot is aborted, the pen will be left in a random position and the external plotter may need to be reset to restore the pen to its start position.

2.4.8 Plot positioning and scaling

The output plot from the DSO has the relative positions shown in figure 2.4.8a. These may be shifted and scaled to position the plot exactly over a pre-defined grid using the following procedure with reference to figure 2.5.8b.

The sides of the pre-defined grid are X and Y, the exact positions of P1 and P2 are found by calculating the dimensions A, B, C and D:

Measure the vertical dimension of the required grid, note this as Y.

Measure the horizontal dimension of the required grid, note this as X.

Using these values of X and Y, A, B, C and D can be calculated as follows:

$$A=\frac{42\ Y}{240} \qquad B=\frac{196\ X}{500}$$

$$C=\frac{703\ X}{500} \qquad D=\frac{310\ Y}{240}$$

Measure and mark the exact positions of P1 and P2 from the grid edges using figure 2.4.8b and the values obtained above.

The P1 and P2 points can now be set on the plotter, refer to the plotter manual for details.

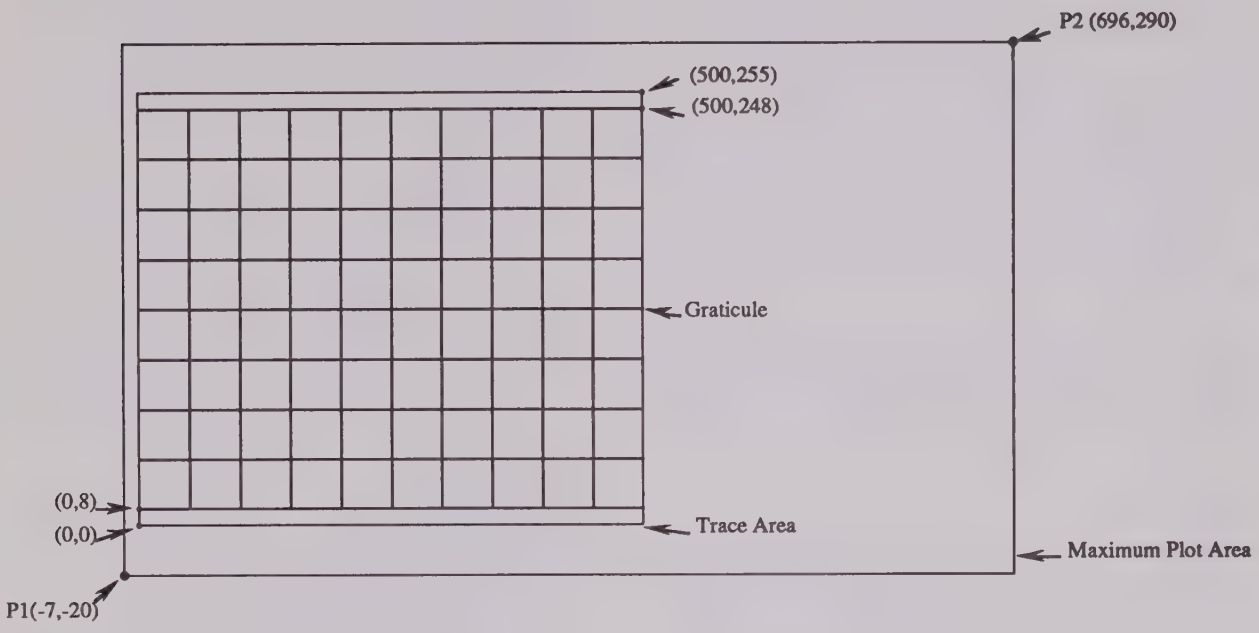


Figure 2.4.8a Relative Plot Positions

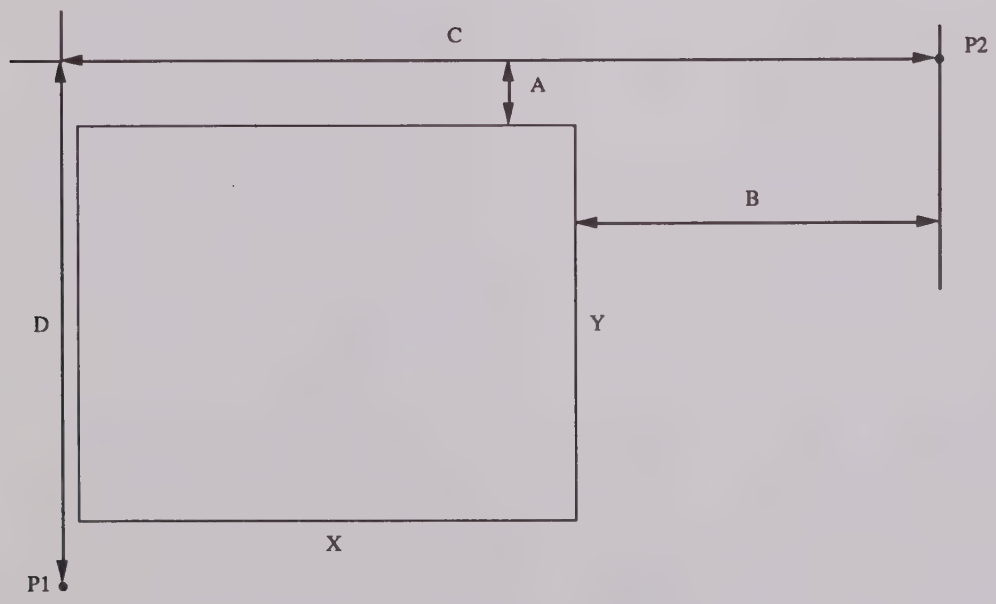


Figure 2.4.8b Plot Dimensions

2.5 Data Transfer

Trace data for either Trace 1, Trace 2 or the reference trace can be transferred to and from the oscilloscope and a computer.

There are four I/O commands which are used for the data transfer, they are: ST1, ST2, ST3 and ST?. The first three commands are used to transfer data and the fourth one to interrogate the DSO for its error status. If, however the instrument is fitted with a GPIB interface, these commands are not supported as the same function can be achieved using SCPI commands.

The data that is output is the complete waveforms, including the reference trace, plus information about the timebase and volts per division. The data is output in a form suitable for HPGL plotters, such as the Gould 6120. See section 3.12.

2.5.1 Syntax

To receive the data for trace one, the computer sends "ST1", The DSO response will be in either of the following forms depending upon whether or not a real time clock is fitted:

ST1=20mV,10us,#dataCRLF

ST1=Jun,09,91,15:27:03,20mV,10us,#dataCRLF

Where # is:

#H for hexadecimal number base.
#O for octal number base.
#B for binary number base.
or nothing for decimal number base.

Data is: the trace information as described below.

CRLF is: carriage return, line feed.

If the DSO receives ST3 and the reference trace is unused, the DSO will respond with "ST3 = UNUSED".

Note: *When data is being sent to the DSO #D may be used for decimal number base.*

For decimal, octal and hexadecimal, the "data" field consists of 501 data points separated by commas.

For binary transfer, the "data" field is as follows:

"lldddd...ddddcc"

Where: ll is 2-byte count of the data that follows including the 2-byte checksum. This will have the value 01F7 (hex) or 503 (decimal). dddd...dddd is 501 bytes of trace data. cc is a 2-byte checksum of the preceding data including the 2-byte length.

The most significant byte is sent first for both the length and checksum fields.

Note that there are no comma separators between data bytes during binary transfer.

The value range for the data points for each number base is as follows:

Decimal:
Each data point is an ASCII encoded signed decimal number.
-128 represents the bottom of the screen,
0 represents the middle of the screen, and
127 represents the top of the screen.
The maximum number of characters per trace transfer is 2521 without a real time clock and 2540 with a real time clock.

Octal:
Each data point is sent as an ASCII encoded unsigned octal number.
000 represents the bottom of the screen,
200 represents the middle of the screen, and
377 represents the top of the screen.
The maximum number of characters per trace transfer is 2022 without a real time clock and 2041 with a real time clock.

Hexadecimal:
Each data point is sent as an ASCII encoded unsigned hex number.
00 represents the bottom of the screen,
80 represents the middle of the screen, and
FF represents the top of the screen.
The maximum number of characters per trace transfer is 1521 without a real time clock and 1540 with a real time clock.

Binary:
Each data point is sent as a single byte.
00000000 represents the bottom of the screen,
10000000 represents the middle of the screen, and
11111111 represents the top of the screen.
The maximum number of characters per trace transfer is 524 without a real time clock and 543 with a real time clock.

2.5.2 Receiving Data

The computer may send strings to the DSO at any time in the same syntax as above. The DSO converts the data into binary form in an internal memory, and when all the data has been collected and verified, transfers the entire memory to the destination trace store.

For decimal, octal, and hexadecimal the DSO will cease receiving as soon as a CR or LF is received, and only then transfer the data received to the required store.

For binary transfer, the DSO will cease receiving when the amount of data indicated by the length field has been received.

Unless the selected trace for received data is held or acquisition is not armed, the selected memory data could be overwritten almost immediately by a fresh acquisition.

Note: The number base for received data is set by the #X field of the incoming string and not by the menu selection. See section 3.7.

The strings for the horizontal and vertical ranges must be exactly as follows, anything else will result in error status 102 being generated.

50s	20s	10s	5s	2s	1s	0.5s
0.2s	0.1s	50ms	20ms	10ms	5ms	2ms
1ms	0.5ms	0.2ms	0.1ms	50us	20us	10us
5us	2us	1us	0.5us	0.25us	0.2us	0.1us
50ns	25ns	5V	2V	1V	0.5V	0.2V
0.1V	50mV	20mV	10mV	5mV	2mV	

2.5.3 Error Status

If the DSO receives "ST?", it will respond with a decimal error status string as follows:

0	No error
96	Invalid command
102	Syntax error
103	Number out of range
104	Length error - Binary transfer only
105	Checksum error - Binary transfer only

If an error condition is detected, the DSO will not make the transfer of data between its internal memory and the destination.

2.6 Real Time Clock

The real time clock, if fitted to the instrument, enables the current date and time together with the date and time of acquisition to appear on any screen plot, and to be transferred to and from a computer if the data transfer facility is used. See section 2.5. When trace data is transferred to the DSO the date and time are checked, if present, to ensure that they are valid and syntax error 102 is returned if they are invalid.

The clock will be kept running for at least ten years, even with the power disconnected, by its own internal battery back-up.

The date and time are set via the special functions menu. See section 3.8.

3. The Menus

The menu structure is summarized in Figure 3. The numbers 1 to 9 refer to the numeric buttons used to select the particular menus and menu items (Section 3.1.1.). All front panel controls remain "live" when menus are displayed, allowing the control status to be changed at any time.

3.1. Additional Buttons

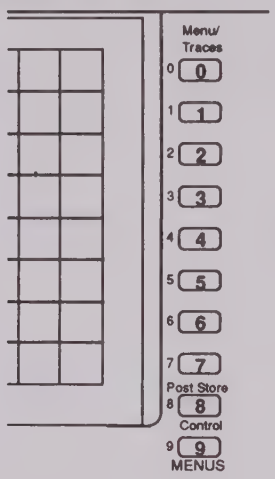


Figure 3.1 The Numeric Buttons

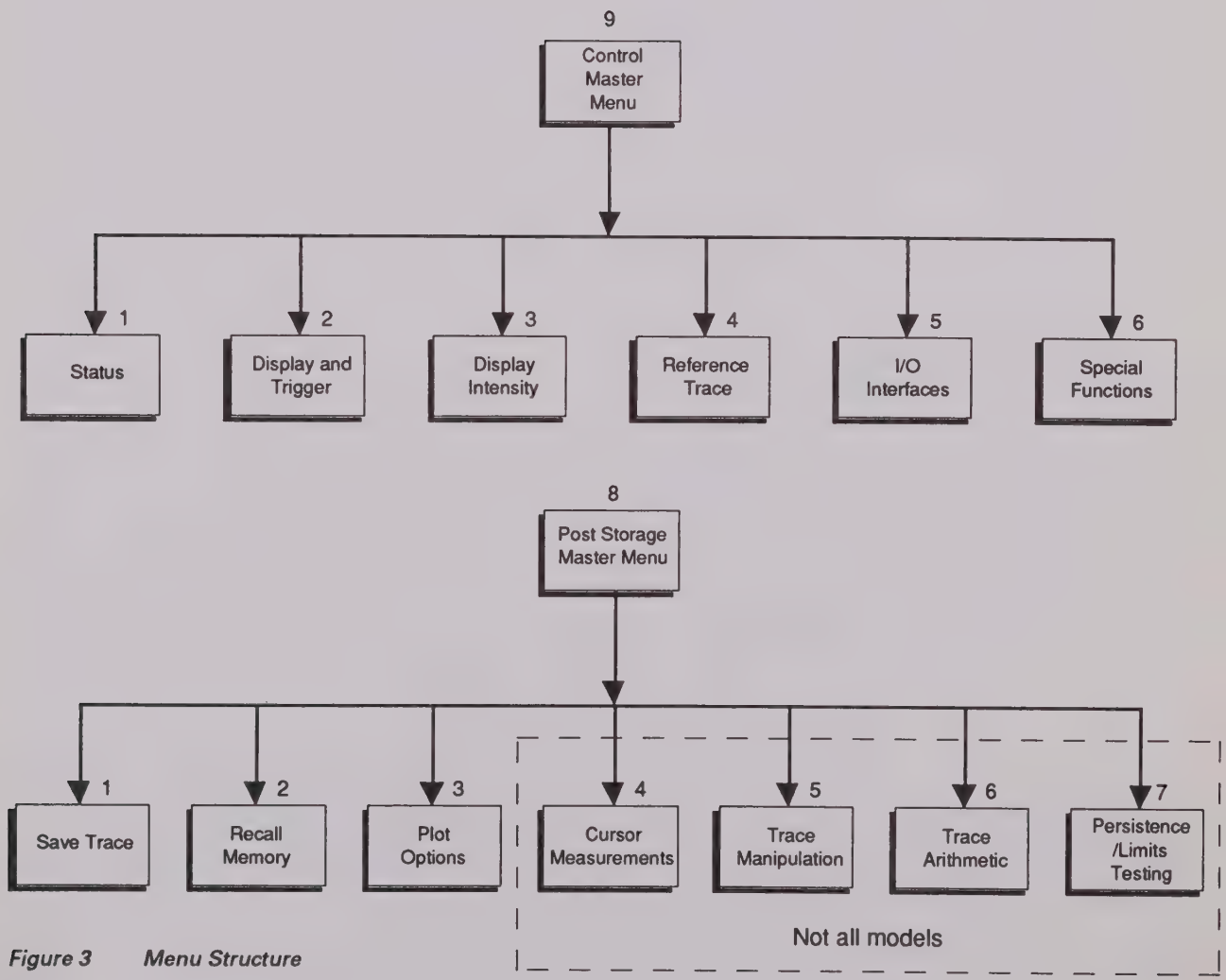


Figure 3 Menu Structure

3.1.1. The Numeric Buttons

The buttons **1** to **7** are used in conjunction with the menu system to provide a large number of extra functions not otherwise available directly from the front panel. Pressing these buttons when the menus are displayed operates the menu functions described in Sections 3.2 to 3.12. Buttons **0, 8** and **9** have extra functions described below.

3.1.2. Menu/Traces

Menu/Traces: (0) Toggles the display between the traces and the last used menu.

3.1.3. Menus

There are two Menu buttons which each select a menu to replace the current display

Control: (9) The current display, whatever it may be, is replaced with the Control Master Menu.

Post Store: (8) Brings the Post Storage Master Menu onto the display.

3.2. Control Master Menu

Each entry on the Control Master Menu is also a menu, covering one set of functions. The text is lined up with the numeric buttons **1-7** on the side of the display. To obtain any secondary menu simply press the relevant button.

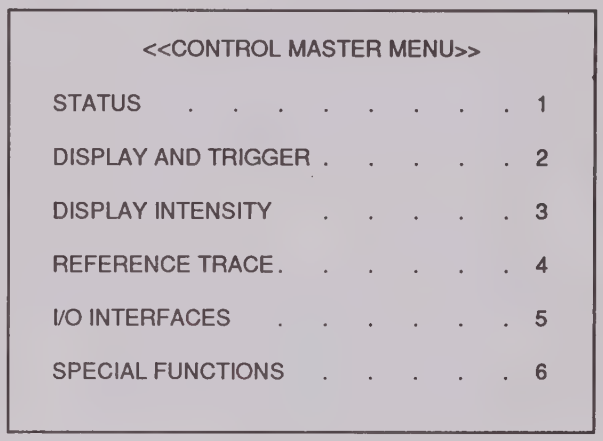


Figure 3.2 The Control Master Menu

The options available on the Control Master Menu are as follows:

STATUS Displays information about the present setup of the instrument. See section 3.3.

DISPLAY AND TRIGGER Controls probe sensitivity, averaging, interpolation, the Max/Min function, and trigger delay. See section 3.4.

DISPLAY INTENSITY The brightness of the alphanumerics, graticule, cursor and traces can all be adjusted independently. See section 3.5.

REFERENCE TRACE Either one of the currently displayed traces can be copied to the reference trace or the reference trace can receive data via the GPIB interface. See section 3.6.

I/O INTERFACES Setting the RS423 or GPIB interface, if fitted, and output protocol. See section 3.7.

SPECIAL FUNCTIONS Enables the user to disable the auto-calibration, calibrate either channel, force a full calibration and set the real time clock if it is fitted. See section 3.8.

3.3. Status Menu

This menu allows the various horizontal, vertical and trigger settings of the instrument to be viewed. Because the front panel controls remain live, changes made to the instrument status will be immediately shown on this menu. A typical display is shown in Figure 3.3.

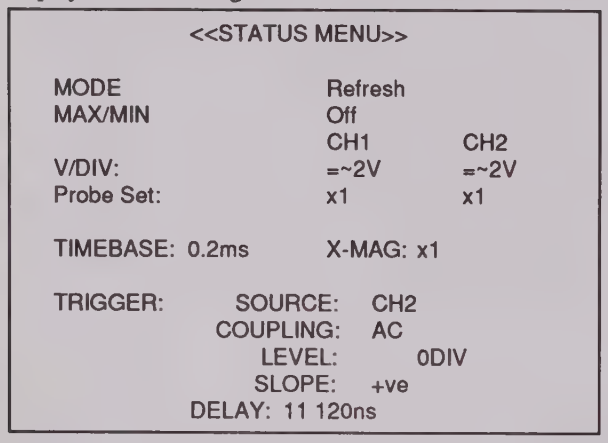


Figure 3.3 A Status Menu

Mode: There are three possible display modes: Refresh, Roll and X-Y. They are described in Section 2.3.

Max/Min: The Max/min detector is selected using the Display and Trigger Menu. See section 3.4.

V/Div: The input sensitivity of the channels is shown in volts per division. The range is 2mV to 5V per division. If Add mode is selected, a + sign is shown between the channels.

Along with the input sensitivity of the channels, other information is also shown. The symbols used are as follows:

– Trace inverted.
> Uncalibrated.
~ AC coupled.
= Calibrated.

Probe Set: The probe gain settings are shown as x1, x10 or x100. These may be set using the Display and Trigger Menu. See Section 3.4.

Timebase: The sweep rate of the timebase is shown in s, ms, µs or ns per division.

Trigger: This section of the display shows the selected trigger options. The choices of source are CH1, CH2, Ext and Line. The available couplings are AC, DC and high frequency reject. These are discussed in Section 2.1.

The trigger level is shown in terms of the number of screen divisions above the bottom of the graticule. The trigger slope is shown as either +ve (rising edge) or -ve (falling edge).

Following this is the trigger delay setting, given in s, ms, µs or ns as appropriate. For pre-trigger operation, the figure is given as a percentage; 0% places the trigger point at the left-hand edge of the screen and 98% near the right-hand edge.

3.4. Display and Trigger Menu

This menu controls probe ratios, max/min detection, interpolation, and the trigger delay function.

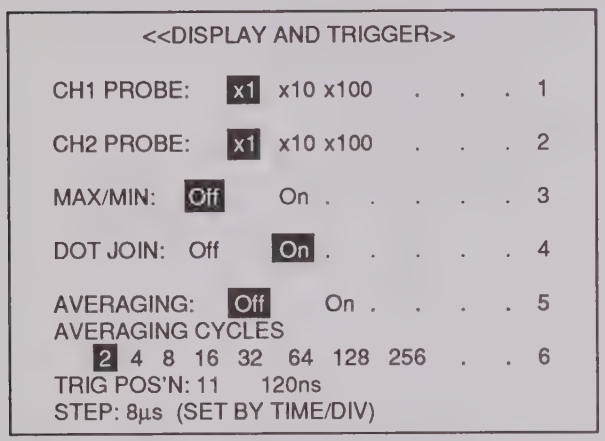


Figure 3.4 Display and Trigger Menu (Trigger Delay)

CH1 & CH2 Probe: An independent probe attenuation ratio can be set for each of the two input channels with successive presses of buttons **1** and **2**. The ratios available are x1, x10 and x100. Thereafter, probes of the chosen ratios may be attached to the appropriate inputs; the new sensitivities at the probe tip will be displayed correctly.

Max/Min: Using the number **3** button, the max/min function can be switched on or off.

The Max/Min function is designed to detect aliases (see section 1.6.2), and can be used to detect glitches which may occur between samples. It operates on the signal before it is placed in the acquisition store and can detect narrow glitches, down to 1µs wide.

Glitches less than 1µs will sometimes be detected and can give an aliasing effect. See section 1.6.2.

Any glitches detected will at least be displayed as a spike. They will be detected whether they are positive (max) or negative (min). The function works in the timebase ranges of 100µs per division down to 50s per division.

Dot Join: Button **4** selects the dot-joining function. On some X-magnified or high speed traces, gaps can be visible between the sample points; if **Off** is selected, the points alone will be displayed. Selecting **On** causes the data to be automatically joined by straight lines.

Averaging: It is possible to improve the signal to noise ratio of repetitive signals by averaging them. This function, which converts the display into weighted average of previous acquisitions is toggled **On** and **Off** by button **5**. Button **6** is used to determine the averaging factor to be used in the algorithm.

$$A_n = \frac{a_n (f-1) + d}{f}$$

Where:

n	=	The data point (1 to 501)
A_n	=	New value at n
a_n	=	Old value at n
f	=	Averaging factor (2 to 256)
d	=	Latest value at n

e.g. In continuous mode, if 8 acquisitions are selected, any single acquisition that deviates from an otherwise consistent level, contributes 1/8 of its deviation to the display. In S/Shot only the selected number of acquisitions contribute to the resultant held display.

Trig Pos'n: This displays the current value of either the pretrigger percentage or the post trigger delay time. The value can be altered as described in section 2.1.6. Figure 2.1.6. shows the display relative to the trigger position for both pre and delay trigger values.

3.5. Display Intensity

This menu allows independent control over the brightness of various display features.

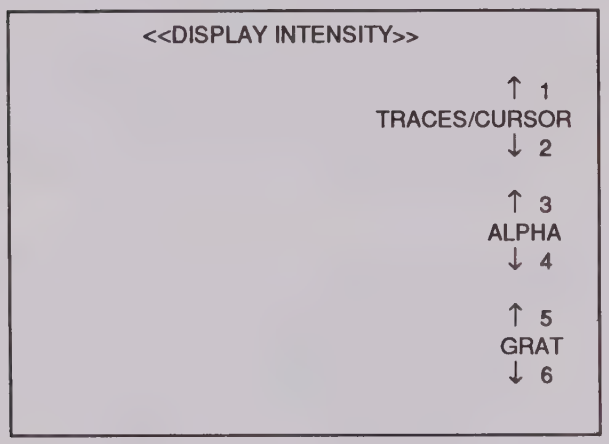


Figure 3.5 Display Intensity Menu

TRACES/CURSOR: The brightness of the cursor, datum lines and all traces will be adjusted. The number **1** key increases the intensity and the number **2** key decreases it.

ALPHA: The brightness of all the alphanumerics will be adjusted. The number **3** key increases the intensity and the number **4** key deceases it.

GRAT: The brightness of the graticule (or grid) will be adjusted. The number **5** key increases the intensity and the number **6** key decreases it.

3.6. Reference Trace

The menu provides the option of temporarily storing a trace for comparison with the two channels. It will be lost when it is replaced with an alternative trace.

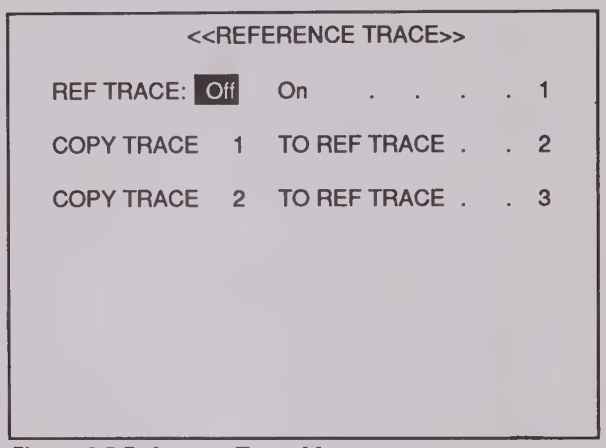


Figure 3.5 Reference Trace Menu

To copy a currently displayed trace into the reference trace, simply press either button **2** or button **3** depending on which trace is required. A copy of the trace will then be taken.

To display a previously stored reference trace use the **1** button to toggle the selection to **On**.

3.7 I/O Interfaces Menu

This menu allows the parameters of the RS423 or GPIB interfaces to be set and has two forms depending on whether or not a GPIB interface is fitted. If GPIB is not fitted, trace data can stil be transferred using the ST commands, see section 2.5.

```
<<I/O INTERFACE MENU>>


RS423 BAUD RATE: 2400  . . . . 3
RS423 HANDSHAKE:
      Off XON-XOFF CTS-RTS  . . 4
RS423 FORMAT: 8-Bit data;
no parity; 1 start, 1 stop bit

NUMBER BASE: DEC HEX OCT BIN. 6

BLOCK LENGTH:  80 . . . . . 7
```

Figure 3.7a I/O interface menu (GPIB not fitted)

```
<<I/O INTERFACE MENU>>

GPIB:  ADDRESSABLE TALK-ONLY .  1

GPIB ADDRESS:  07 . . . . . 2

RS423 BAUD RATE: 2400  . . . . 3
RS423 HANDSHAKE:
      Off XON-XOFF CTS-RTS  . . 4
RS423 FORMAT: 8-Bit data;
no parity; 1 start, 1 stop bit


REMOTE CHANNEL: GPIB RS423 . . 7
```

Figure 3.7a I/O interface menu (GPIB fitted)

With GPIB fitted, full remote control, including trace data transfer, is possible using SCPI commands via GPIB or RS423 depending on which remote channel is selected.

GPIB The GPIB interface can be set to be Addressable or set to be a talk only device using button **1**.

The GPIB line only appears if the GPIB option is installed in the DSO.

If the plot output has previously been set to GPIB, selecting ADDRESSABLE is not permitted. Attempting to do so will result in the screen error message:

PLOT OUTPUT MUST NOT BE GPIB

GPIB Address Press button **2** to set the GPIB address to any address number in the range 0 to 30.

The GPIB address line only appears if the GPIB option is installed in the DSO and set to be addressable.

RS423 Baud Rate: This is selected with button **3.** The baud rate may be 75, 150, 300, 600, 1200, 2400, 4800 or 9600 baud.

RS423 Handshake: Key **4** is used to select from handshaking **Off, XON-XOFF,** or **CTS-RTS.**

RS423 Format The data format is fixed with no parity, one start bit, eight data bits and one stop bit.

Remote Channel: Button **7**, when a GPIB interface is fitted is used to select between GPIB and RS423 remote control.

Number Base: Button **6** sequentially selects from decimal, hexadecimal, octal and binary as the number base to be used in any RS423 data transmission from the DSO. See section 2.6.

This line only appears if the GPIB option is NOT installed

Block Length: successive press of button **7** changes the block length from 0 to 80 in steps of 10 i.e. the sequence 0, 10, 20, 30, 40, 50, 60, 70, 80, 0... A block length of 0 selects infinite length blocks.

During data output from the DSO, if the next value to be sent would exceed the block length, then a CRLF is sent instead of a comma. Block length has no effect on binary transfers, all bytes of data are always sent.

This line only appears if the GPIB option is NOT installed

Interface Connections

3.7.1. RS423 Plot Connections

The RS423 port is configured at the factory as shown in table 3.7.1. The instrument can be connected to a Gould colorwriter 6120 or 6320 or a HP7475 plotter using the Gould plotter cable part number 0409-1232. The connections of this cable are shown in figure 3.7.1.

Pin No.	Name	Description
1	0V	Protective Ground
2	RXD	Receive Data
3	TXD	Transmit Data
4	CTS	Clear to Send
5	RTS	Request to Send
7	0V	Signal Ground
9	0V	Ground
18	0V/5V	Limits Test Fail

Table 3.7.1 Standard RS423 Port Pin Connections

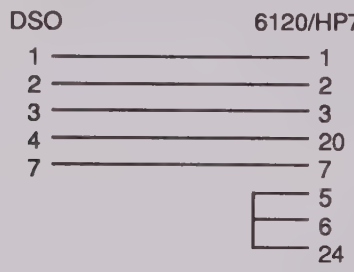


Figure 3.7.1 DSO to Gould 6120 or HP7475 Connections

3.7.2. RS423 Data Connections

To connect the DSO to a computer, use the connections shown in figure 3.7.2a or figure 3.7.2b. A prewired cable for each of these arrangements is available; part number 0410-9248 for the PC/XT and part number 0410-1247 for the AT.

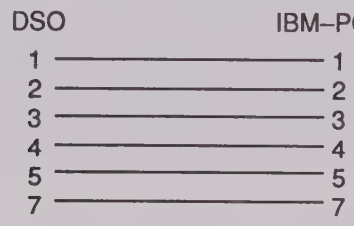


Figure 3.7.2a DSO to IBM-PC/XT Connections

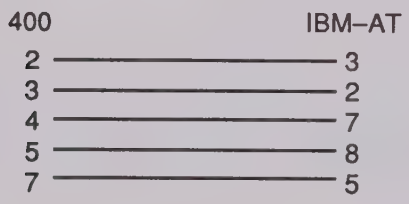


Figure 3.7.2b DSO to IBM-AT Connections

3.7.3. IEEE Data Connections

To connect the DSO to a computer, use the IEEE connections shown in Appendix 5. A prewired cable for this connection is available; part number 453296.

3.8. Special Functions

This menu controls the selection of auto calibration and can force the instrument to perform a full calibration.

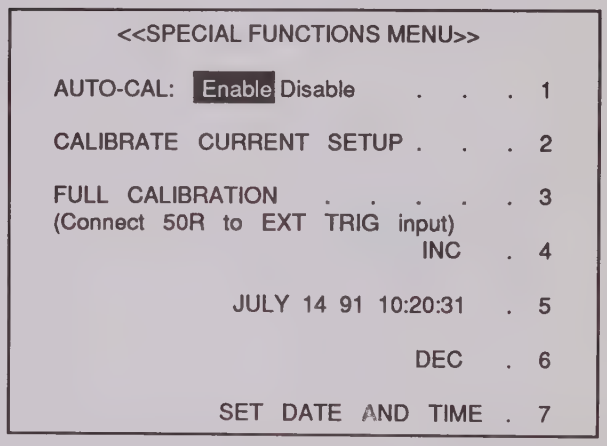


Figure 3.8 Special Functions Menu

AUTO-CAL: pressing button 1 enables or disables the instrument's automatic re-calibration procedure.

When Auto-cal is enabled, the change of any vertical or timebase range which is due for calibration will, after a 2 second pause, initiate a calibration of the new operating conditions. If the operating conditions are not changed, a recalibration is initiated at 15 minute intervals. Each calibration takes about one second.

If the occasional interruption of the normal function of the instrument is unacceptable to the user the Auto-cal facility can be disabled as described above. Recalibration is then recommended 30 minutes after switch on from cold, and additionally if there is a significant change in the ambient operating temperature.

CALIBRATE CURRENT SETUP: Pressing button 2 forces the instrument to recalibrate for the vertical range and mode and the timebase range at which it is currently set. The actual calibration occurs approximately 2 seconds after pressing the button. This feature does not operate when the instrument is in Continuous Roll mode.

FULL CALIBRATION: Button 3 forces the instrument to perform a complete internal recalibration ignoring existing information.

When performing a full calibration connect a 50Ω termination to the Exit Trig input. This ensures that the trigger input is correctly calibrated for a 50Ω source signal.

All internal memories are cleared including the instrument status data and any stored traces. To obtain the best results from this calibration, the instrument must have been operating for a minimum of 30 minutes. This calibration should only be required if there have been repairs to the signal processing sections of the unit or if the internal battery maintaining the status memories has been totally discharged or disconnected.

Note: *No auto–calibrations will be performed if the instrument is armed, in a data capture cycle, in continuous roll mode or if Auto-cal is disabled, they will simply be postponed until these conditions end. Full calibration is always available.*

REAL TIME CLOCK: The real time clock is set using buttons 4, 5, 6 and 7 on this menu. The entire date and time is displayed, with one section highlighted. The highlighted element is selected using button **5** and can then be increased or decreased using button **4** or **6** as appropriate.

Once the correct date and time has been set, pressing button **7** enters the data. This makes it easy to set a time that is a few seconds in advance of real time and then press button **7** at a time signal. If the menu is exited without pressing button **7**, then the date and time will remain unchanged.

The clock is kept running even with the power disconnected for at least ten years by its own internal battery backup.

3.9 Post Storage Master Menu

The first three items on this menu provide access to three further menus which control the operation of the battery backed trace memories and the plotter.

<<POST STORAGE MASTER MENU>>

SAVE TRACE 1

RECALL MEMORY 2

PLOT OPTIONS 3

CURSOR MEASUREMENTS 4

TRACE MANIPULATION 5

TRACE ARITHMETIC 6

PERSISTENCE/LIMITS TESTING . . . 7

Figure 3.9 Post Storage Master Menu

The other four items on this menu are only available on instruments fitted with the waveform processing option. Their operation is described in section 5.

3.10. Save Trace Menu

This menu allows you to store traces, including the reference trace, to the battery backed memories.

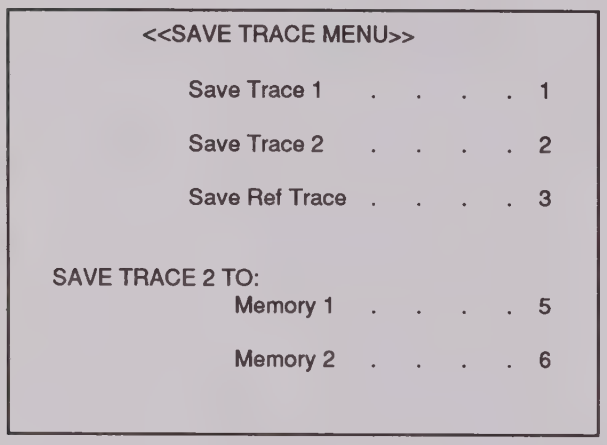


Figure 3.10 Save Trace Menu

Because these memories are battery-backed, the traces stored in them will not be lost even when the instrument is powered down.

SAVE TRACE: Using the **1**, **2** or **3** keys selects either Trace 1, Trace 2, or the Reference Trace respectively to be saved. Once the trace has been selected, a fresh option will appear, described below.

SAVE TRACE TO MEMORY: Either of the battery-backed memories may be selected as the destination in which to store the selected trace.

3.11. Recall Memory Menu

Traces previously saved using the Save Trace menu can be recalled using this menu.

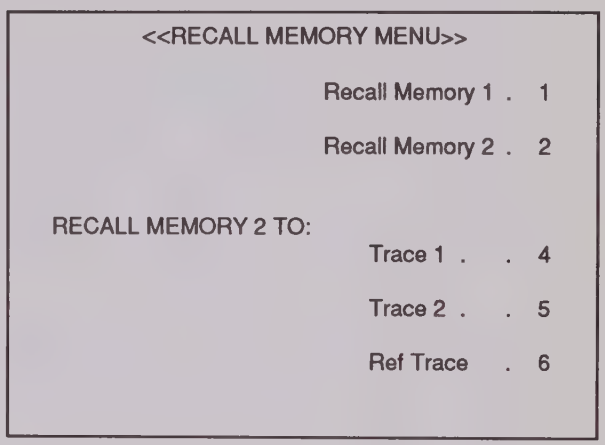


Figure 3.11 Recall Memory Menu

RECALL MEMORY: One of the memories may be recalled by pressing the appropriate button, **1** or **2**. Having chosen a memory, you will be asked into which display trace you would like to place it.

RECALL MEMORY TO TRACE: Pressing button **4**, **5** or **6** will cause the trace data from the previously selected memory to be displayed on trace 1, trace 2, or the reference trace.

Note: *Unless the selected trace is held, or acquisition is not armed, the selected memory data could be over-written soon after it is displayed.*

3.12. Plot Menu

This menu allows the user to set the format of the plot sent to the internal color plotter or to the external plotter via the RS423 or GPIB interface. Refer to Section 3.7 for RS423 connections.

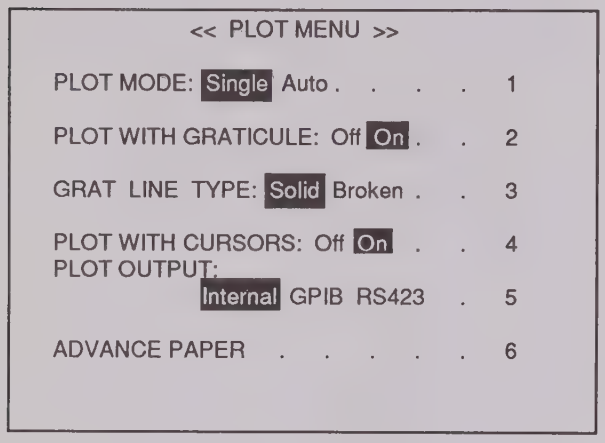

<< PLOT MENU >>
PLOT MODE: Single Auto 1
PLOT WITH GRATICULE: Off On . . 2
GRAT LINE TYPE: Solid Broken . . 3
PLOT WITH CURSORS: Off On . . 4
PLOT OUTPUT:
Internal GPIB RS423 . 5
ADVANCE PAPER 6

Figure 3.12. Plot Menu

PLOT MODE: This can be set to either Single or Auto with successive presses of the number **1** button. In Single plot mode one press of the Plot button will produce one plot output. In Auto mode, a press of the Plot button (10) will initiate a plot. The sequence thereafter continues automatically. At the end of the plot the trigger circuit is rearmed for the next acquisition, and at the end of an acquisition, the plot is started. An external plotter must have an auto feed facility to function correctly in this mode. If it does not, then the feed command from the DSO may confuse the plotter.

PLOT WITH GRATICULE: The user has the option of including the screen grid in the plots with **On** or excluding it with **Off.**

GRAT LINE TYPE: A solid or broken graticule can be selected for the plot, by successive presses of button **3.**

PLOT WITH CURSORS: If **On** is selected, then any plots made will include the cursor and datum lines and the selected measurement data. Otherwise, they will be omitted.

PLOT OUTPUT: This line only appears if the instrument is fitted with an internal color plotter or a RS423 or IEEE interface or combination of these. The selections available change depending on the options fitted.

The internal plotter is automatically selected on cold start if it is fitted. If required the plot output can be directed, using button **5**, via the RS423 or GPIB port to an external plotter by selecting RS423 or GPIB.

To plot via the GPIB it must be set to talk only mode. If GPIB is set to addressable on the I/O interface menu, GPIB cannot be set as the plot destination. Attempting to do so will result in the screen message

GPIB MUST NOT BE ADDRESSABLE

ADVANCE PAPER: Pressing button **6** when the internal plotter is selected causes the paper to be advanced approximately 15mm per press. This line only appears if the internal plotter is selected on line 5.

4. Performance Checking

The aim of this section is to allow the user to verify the major analog performance parameters of the oscilloscope. Should any of these fail to be within specification then it is recommended that the instrument be re-calibrated. A skilled technician with the aid of the service manual should be able to perform this task; alternatively return the instrument to your local distributor.

4.1. Risetime

Equipment required:

Fast edge pulse generator <1ns: Bradley oscilloscope calibrator type 192 or Tektronix PG506 or similar;
50 Ohm precision coaxial cable;
50 Ohm precision terminator.

Connect the pulse generator to a channel input through the coax cable and the terminator, which should be at the DSO end of the cable.

1. Select 100mV per division on the input channel and set the timebase to 5µs per division.
2. Set the generator to give 600mV peak to peak at a repetition rate of 1MHz and adjust the trigger level to give a stable trace.
3. Select the cursor and change the timebase to the fastest range and select 50% pre trigger.
4. Apply x10 trace magnification using the **Mag** button, and adjust the horizontal **Position** buttons to center the fast edge.
5. Position the cursor and datum lines on the edge such that the cursor is 60mV below the high level and the datum lines cross 60mV above the low level.

The risetime can now be read from the cursor line on the bottom row of text. This figure should not be greater than 17.5ns on a 20MHz set, 7ns on a 50 MHz set or 3.5ns on a 100MHz set.

Note: On a set fitted with the measurements option, rise time can be selected from the cursor measurements menu.

4.2. Bandwidth

Equipment required:

Leveled signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the DSO end of the cable.

1. Select 5mV per division on the input channel and set the timebase to 50µs per division.
2. Set the amplitude of the signal generator to give six divisions at 50kHz or similar reference frequency.
3. Change the timebase range to 0.5µs per division.
4. Increase the frequency on the signal generator until the peak to peak amplitude reduces to 4.2 divisions.

The measured frequency should be greater than 20, 50 or 100MHz depending on instrument type.

4.3. Trigger Sensitivity

Equipment required:

Signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to a channel input through the coax cable and the terminator, which should be at the DSO end of the cable.

1. Select 100mV per division on the input channel and set the timebase to 50µs per division.
2. Select **Auto** trigger.
3. Set the signal generator to 50kHz or similar reference frequency and adjust the amplitude to give 0.3 of a division peak to peak.
4. Select AC Coupling and **Norm** on the trigger controls.

It should be possible to find a suitable trigger level to give a stable triggered trace.

4.3 Trigger Bandwidth

Equipment Required:

Leveled signal generator: Tektronix SG503 or similar.
50 Ohm coaxial cable;
50 Ohm terminator;

Connect the signal generator to a channel input through the coax cable and the terminator - which should be at the instrument end of the cable.

1. Select 100mV per division on the input channel and set the timebase to 0.5µs per division.

2. Set the amplitude of the signal generator to give three divisions at 50kHz or similar reference frequency.
3. Select **AC** coupling and **Norm** on the trigger controls.
4. Without adjusting its amplitude, set the signal generator to 20MHz, 50MHz or 100MHz depending on the instrument type

It should be possible to adjust the trigger level to give a stable trace.

4.5. Timebase Calibration

Equipment required:

Time calibrator: Bradley oscilloscope calibrator type 192 or Tektronix TG501 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the calibrator to a channel input through the coax cable and the terminator, which should be at the DSO end of the cable.

1. Select a suitable timebase range to view the signal and set the channel attenuator to give between two and five vertical divisions of signal.
2. Select **DC** Coupling and **Norm** on the trigger controls.
3. Adjust the trigger level to give a stable trace.
4. Change the timebase to 0.5µs per division.
5. Set the calibrator to produce markers every 0.5µs.
6. Select the cursors.

With the cursor and time datum on identical positions on any two markers, the time difference should read in multiples of 0.5µs to with 1%.

Note: *Failure of this specification point is indicative of a major system fault and the instrument should be serviced immediately.*

4.6. Vertical Calibration

Equipment required:

Oscilloscope calibrator: Bradley type 192 or similar;
Coaxial cable.

Connect the vertical calibration output of the oscilloscope calibrator to the DSO through the coax cable.

1. Set the timebase to 500µs per division and select 5mV per division for the input channel.
2. Set the calibrator to give 30mV peak to peak, i.e. 6 screen divisions.
3. Adjust the trigger level to give a stable picture.
4. Switch the cursor on.

The peak to peak measurement should be 30mV to within 3% and the trace should be 6 divisions high to ±0.1 divisions.

These measurements should be repeated on all the attenuator ranges, each time setting the calibrator to 6 screen divisions for the selected range.

4.7. Max-Min (Alias Detector)

Equipment required:

Signal generator: Tektronix SG503 or similar;
50 Ohm coaxial cable;
50 Ohm terminator.

Connect the signal generator to an input channel through the coax and the terminator, which should be at the DSO end of the cable.

1. Set the timebase to 0.5µs per division and select 100mV per division on the input channel.
2. Set the generator to give approximately 5 divisions at 0.4MHz and adjust the trigger level to give a stable trace.
3. Select 1ms per division on the timebase. You should notice that the screen picture will change considerably with small changes in input frequency. The result on the screen is an alias.
4. Select the Max-Min function from the Display and Trigger Menu.

If Max-Min is functioning correctly a wide band will be displayed showing the peak excursions of the signal.

5. WAVEFORM PROCESSING FUNCTIONS

All the waveform processing functions are accessed through the Post-Storage Master Menu. Selections 1, 2 and 3 on this menu perform as described in section 3.9 to 3.12.

Selections 4 to 7 provide the waveform processing functions.

When performing any waveform processing that modifies a displayed trace, the new data could be overwritten almost immediately by a fresh acquisition unless the selected trace is held or further acquisitions are prevented e.g. the instrument is in single shot mode and the trace stored or no triggers are provided.

5.1 Cursor Measurements

The DSO has 3 user controlled lines for use with this section of facilities. Their operation is fully described in section 2.4. The cursor is moved along the selected trace using the < and > cursor buttons (44) & (45), the two datum lines are moved using the datum buttons (40) to (43); the time datum line moves with < and > and the voltage datum with ^ and v .

Pressing button **4** on the Post Storage Master Menu changes the display to the Cursor Measurements Menu - figure 5.1a. The cursor is used to determine the trace of interest and for some measurements the cursor and time datum lines define the portion of the trace to be measured. Most trace measurements are with respect to the voltage datum line.

```
<< CURSOR MEASUREMENTS MENU>>

CALCULATION 1:
    Freq, Period & Duty-cycle . . . 2
CALCULATION 2:
    Pulse width . . . . . 3
CALCULATION 3:
    Voltage & Time . . . . . 4

REFERENCE:  Pulse  Width  Left.  .  5

                          INC .  6
                  30%
                          DEC.   7
```

Figure 5.1a. Cursor Measurements Menu

Three simultaneous calculations are possible using buttons **2, 3** and **4**. Each calculation is selected from a roll around list containing the following options: Voltage & Time, Peak to Peak, Max & Min, Risetime (falltime), Overshoot (preshoot), Pulse Width, Frequency, Period, Duty Cycle, RMS, Area and off.

Several of these calculations automatically perform a Top and Base measurement (see section 5.1.1) to obtain the requested result.

A calculation can only be selected once e.g. if calculation 1 is set to its default of Voltage & Time, then Voltage & Time will not appear in the possible selections for calculations 2 or 3.

If any of the calculations are set to either Pulse Width or Risetime, lines 5, 6 and 7 are displayed. See sections 5.1.4 and 5.1.6

The calculation results are displayed in the three lines at the bottom of the trace display; figure 5.1b shows an example. Cursor measurements on ETS - equivalent time sampling - timebase ranges, are only valid on traces that the cursor is on and that are triggered.

If all the cursor measurements are set to off, the cursor data line on the display will show a message of the form; "TRI CURSOR MEASUREMENTS OFF", and if the data is invalid for the measurement selected, the cursor line will display a message of the form "TR1 INVALID DATA". The trace number in both the above messages will change according to the selected trace.

```
CH1=0.2V      CH2=20mV      X-MAG ON
TB=0.5µS      Y-MAG: x1.438    AFTS
                            RESTORE 1

TR1 LIMIT TEST: PASS        DEL= 12.80µs
TR1 RISE/FALL (10%/90%)       123.4µs
TR1 Max 2.87V                 MIN -2.6V
TR1 12.0kHz  83.00µs           48.2%
```

Figure 5.1b. Example of Calculations on Trace

5.1.1 Top and Base Measurement

To obtain some waveform measurements, the DSO performs an automatic Top & Base measurement as defined in the IEEE Standard on Pulse Measurement and Analysis by Objective Techniques: 181-1977.

The IEEE 194-1977 standard defines various parts of a pulse or edge waveform.

Under most circumstances the Top and Base levels, of a waveform between the time datum and cursor lines, are determined by taking the most common point above the mean of the waveform as the top, and the most common point below the mean as the base.

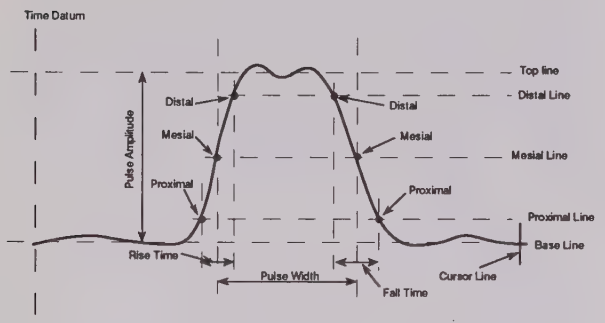


Figure 5.1.1 Waveform Measurement Points

Two kinds of waveforms can change the method of determining the Top and base.

Firstly, if these points do not occur for more than 10% of the time, the maximum and minimum of the waveform is taken to be the Top and Base. This prevents noisy signals producing erroneous results.

Secondly, if the difference between the mean and the maximum or the mean and the minimum levels of the waveform is less than 1/4 of a division, the maximum and minimum of the waveform is taken to be the Top and Base. This ensures that waveforms such as pulse trains with a low mean do not give erroneous results.

5.1.2 Voltage & Time

The display shows the voltage between the voltage datum line and the point where the cursor line crosses the trace and the time between the time datum line and the cursor line.

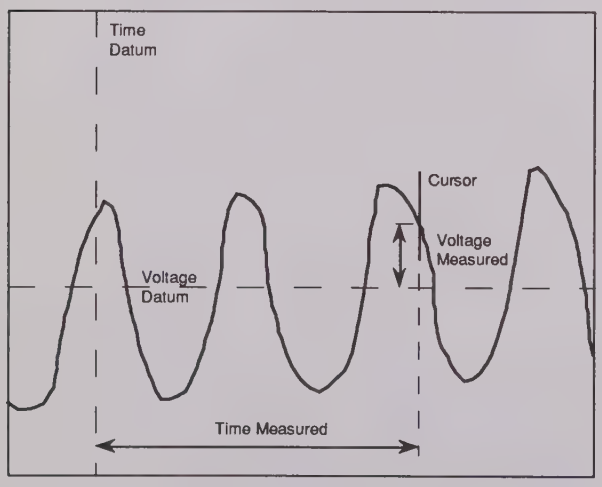


Figure 5.1.2. Voltage & time Measurement

5.1.3 Peak to Peak

The display will show the peak to peak voltage difference between the most positive and negative points of the trace between the cursor and the time datum.

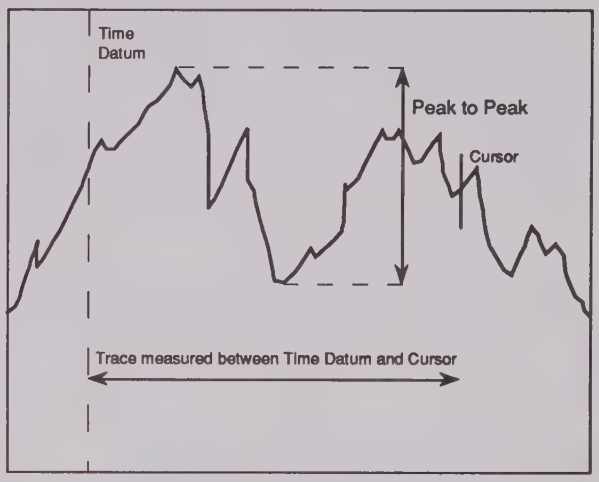


Figure 5.1.3. Peak to Peak Measurement

5.1.4 Max & Min

The display shows the voltages of the maximum and minimum points of the waveform between the cursor and time datum measured with respect to the voltage datum.

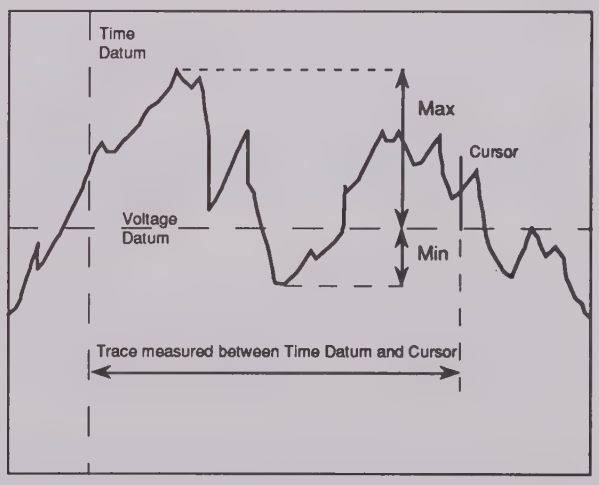


Figure 5.1.4. Max & Min Measurement

5.1.5 Risetime (falltime)

The cursor and the time datum enclose the rising or falling edge of interest, the edge measured will be the first edge from the left hand side of the defined area. The DSO will perform a top & base measurement to determine the 0% and 100% points and then calculate the rise or fall time between the low and high percentage points of the waveform.

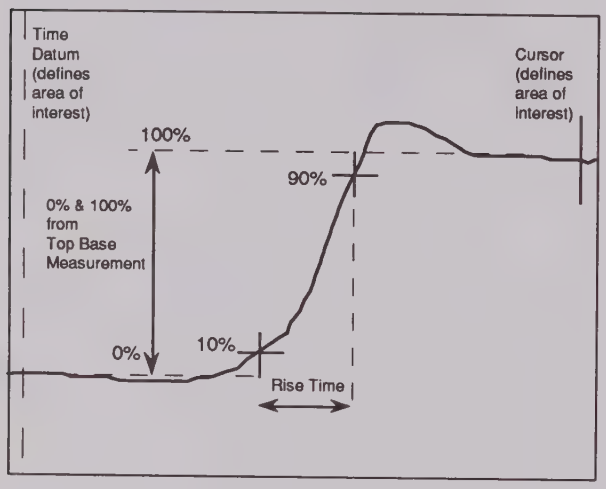


Figure 5.1.5. Risetime Measurement

The default percentage points are 10% and 90%. Using buttons 5, 6 and 7 these values can be changed. Button 5 selects the point to be changed, either Risetime High or Risetime Low. When the appropriate point is selected, it can be changed by pressing button 6 or 7 as required. Low can be set from 0 to 49% in 1% steps and high from 51 to 100% also in 1% steps.

Percentages set are retained even on power down, but are reset to their default vales if a full calibration is performed.

If Pulse Width is also selected as one of the calculations, pressing button 5 steps around 4 entries; Risetime Low, Risetime high, Pulse Width Left and Pulse Width Right.

5.1.6 Overshoot (preshoot)

The cursor and the time datum enclose the overshoot or preshoot area of interest, the measured result will be the first over or pre shoot voltage from the left hand side of the defined area.

The DSO performs a Top & Base measurement to determine the 0% and 100% points and then calculates the overshoot as a percentage of the voltage difference between the 0% and 100% points.

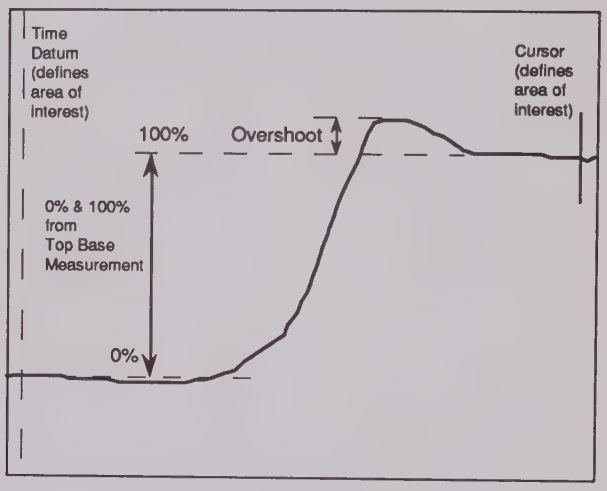


Figure 5.1.6 Overshoot Measurement

5.1.7 Pulse Width

The cursor and the time datum define the pulse to be measured. The first pulse from the left hand side of the defined area will be measured and if the leading edge of this pulse is noisy, the noise may be taken as a pulse and be measured rather than the pulse of interest.

The DSO performs a Top & Base measurement and then measures the time between the 50% - or user defined percentage points of a pulse.

Either positive or negative pulses can be measured.

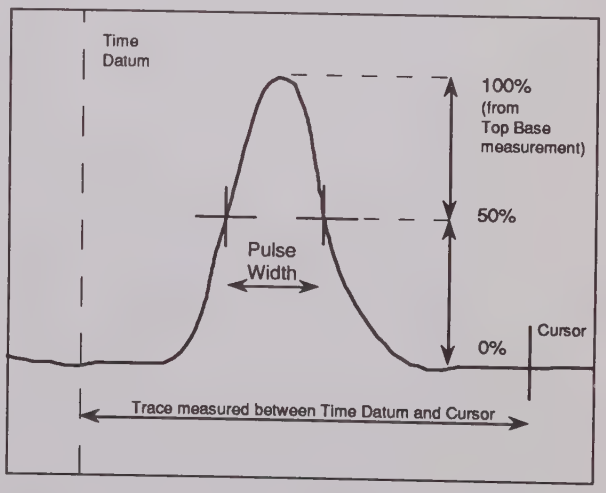


Figure 5.1.7. Pulse Width Measurement

The default percentage points are 50% and 50%. Using buttons 5, 6 and 7 these values can be changed. Button 5 selects the point to be changed, either Pulse Width Left or Pulse Width Right. When the appropriate point is selected, it can be changed by pressing button 6 or 7 as required. Both of them can be set from 5% to 95% in 1% steps.

Percentages set are retained even on power down, but are reset to their default vales if a full calibration is performed.

If Risetime is also selected as one of the calculations, pressing button 5 steps around 4 entries; Pulse Width Left, Pulse Width Right, Risetime Low and Risetime High.

5.1.8 Frequency, Period, Duty Cycle

The three parameters frequency, period and duty cycle of a waveform are displayed with this selection. The voltage datum defines the zero crossing voltage. The cursor and time datum must enclose at least three zero crossings.

If the voltage datum does not cross the trace, the mean of the waveform will be taken as the zero crossing line.

The frequency is the inverse of the period calculated above.

The duty cycle is the ratio of the mark to whole pulse period expressed as a percentage. The left most of either the time datum or cursor defines which part of the waveform is defined as the mark and which the space. e.g if the datum is to the left of the cursor and intersects a low part of the waveform, the space is considered to be the low part of the waveform.

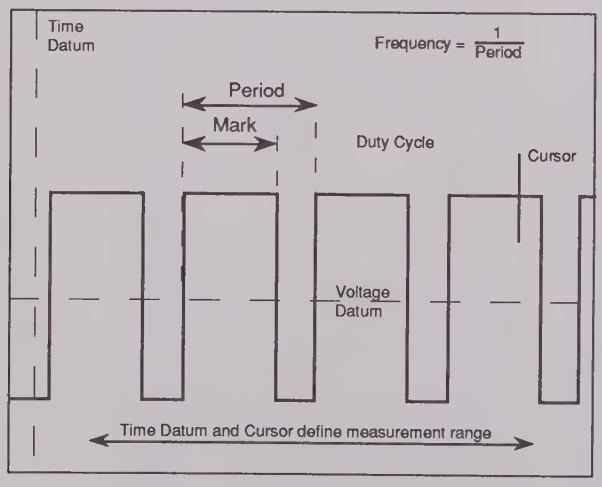


Figure 5.1.8. Freq. Period and Duty Cycle Measurement

For duty cycle measurements, if the voltage datum does not cross the trace, the mid point of the waveform between its the top and base levels will be taken as the zero crossing line. This is known as the mesial level.

5.1.9 RMS & AC RMS

This selection calculates and displays both the RMS voltage with respect to the voltage datum and the AC-RMS voltage with respect to the mean of the trace. Both voltages are calculated on the waveform bounded by the cursor and time datum.

5.1.10 Area

This selection calculates the area bounded by the trace and the cursor and the datum lines.

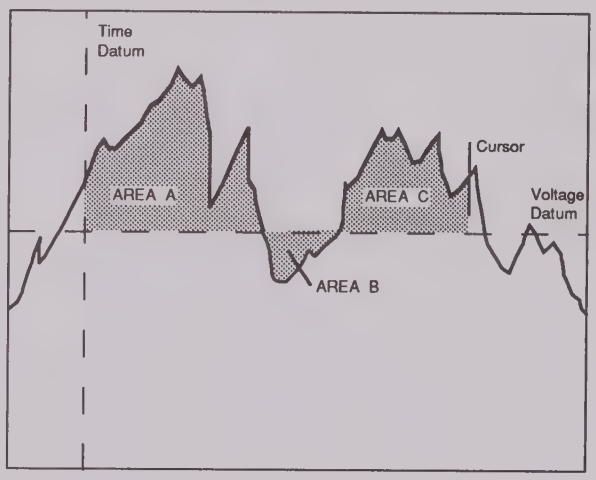


Figure 5.1.10. Area Measurement

The result is given in volt-seconds or similar units.

If the trace falls below the voltage datum (area B in figure 5.1.10) then the area below the datum will be negative. Positive and negative areas are added algebraically to obtain the displayed result.

5.2 Trace Manipulation

Pressing button 5 on the Post Storage Master Menu changes the display to the Trace Manipulation Menu - figure 5.2. The trace to be manipulated is selected with the cursor and the required function with button **2, 3** or **5.**

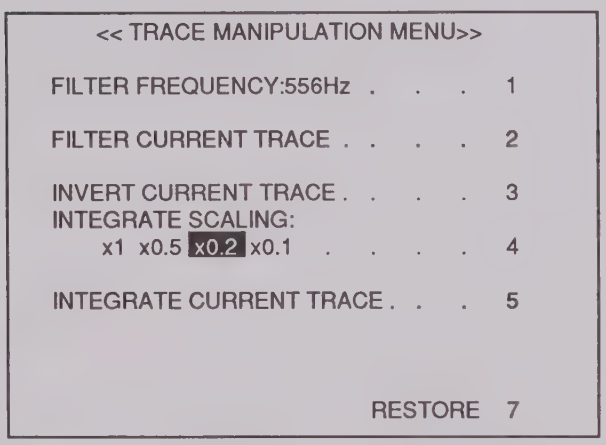


Figure 5.2. Trace Manipulation Menu

If no trace is selected when button **2, 3** or **5** is pressed, the warning message "NO TRACE SELECTED" will be displayed.

Trace manipulations are with respect to the voltage datum line.

After any trace manipulation has been performed pressing button **7** labeled Restore, will return the display to the original stored waveform.

5.2.1 Filter Frequency

The trace can be filtered by a single low pass filter and the 3dB point displayed on the trace display.

The frequency of the filter applied to the waveform when button **2** is pressed is selected using button **1.**

One of six filter stages can be chosen from the roll-around list. The actual frequencies available depend on the current timebase as shown in table 5.2.1.

Timebase	F1	F2	F3	F4	F5	F6
50s	111mHz	45.5mHz	21.3mHz	10.3mHz	5.05mHz	2.51mHz
20s	278mHz	114mHz	53.2mHz	25.8mHz	12.6mHz	6.27mHz
10s	556mHz	227mHz	106mHz	51.5mHz	25.3mHz	12.5mHz
5s	1.11Hz	455mHz	213mHz	103mHz	50.5mHz	25.1mHz
2s	2.78Hz	1.14Hz	532mHz	258mHz	126mHz	62.7mHz
1s	5.56Hz	2.27Hz	1.06Hz	515mHz	253mHz	125mHz
500ms	11.1Hz	4.55Hz	2.13Hz	1.03Hz	505mHz	251mHz
200ms	27.8Hz	11.4Hz	5.32Hz	2.58Hz	1.26Hz	627mHz
100ms	55.6Hz	22.7Hz	10.6Hz	5.15Hz	2.53Hz	1.25Hz
50ms	111Hz	45.5Hz	21.3Hz	10.3Hz	5.05Hz	2.51Hz
20ms	278Hz	114Hz	53.2Hz	25.8Hz	12.6Hz	6.27Hz
10ms	556Hz	227Hz	106Hz	51.5Hz	25.3Hz	12.5Hz
5ms	1.11kHz	455Hz	213Hz	103Hz	50.5Hz	25.1Hz
2ms	2.78kHz	1.14kHz	532Hz	258Hz	126Hz	62.7Hz
1ms	5.56kHz	2.27kHz	1.06kHz	515Hz	253Hz	125Hz
500µs	11.1kHz	4.55kHz	2.13kHz	1.03kHz	505Hz	251Hz
200µs	27.8kHz	11.4kHz	5.32kHz	2.58kHz	1.26kHz	627Hz
100µs	55.6kHz	22.7kHz	10.6kHz	5.15kHz	2.53kHz	1.25kHz
50µs	111kHz	45.5kHz	21.3kHz	10.3kHz	5.05kHz	2.51kHz
20µs	278kHz	114kHz	53.2kHz	25.8kHz	12.6kHz	6.27kHz
10µs	556kHz	227kHz	106kHz	51.5kHz	25.3kHz	12.5kHz
5µs	1.11MHz	455kHz	213kHz	103kHz	50.5kHz	25.1kHz
2µs	2.78MHz	1.14MHz	532kHz	258kHz	126kHz	62.7kHz
1µs	5.56MHz	2.27MHz	1.06MHz	515kHz	253kHz	125kHz
0.5µs	11.1MHz	4.55MHz	2.13MHz	1.03MHz	505kHz	251kHz
0.25µs	22.2MHz	9.09MHz	4.26MHz	2.06MHz	1.01MHz	501kHz
0.2µs	27.8MHz	11.4MHz	5.32MHz	2.58MHz	1.26MHz	627kHz
0.1µs	55.6MHz	22.7MHz	10.6MHz	5.15MHz	2.53MHz	1.25MHz
50ns	111MHz	45.5MHz	21.3MHz	10.3MHz	5.05MHz	2.51MHz
25ns	222MHz	90.9MHz	42.6MHz	20.6MHz	10.1MHz	5.01MHz

Table 5.2.1. Filter Frequencies

5.2.2 Filter Current Trace

To perform the filtering, using the frequency previously set, press button **2**.

5.2.3 Invert Current Trace

To invert the selected trace about the voltage datum, press button **3**. To revert the display to the original trace, press button **1**.

5.2.4 Integrate Scaling

To allow an integrated waveform to fit on the screen a scaling factor can be applied to the integrate function. Pressing button **4** steps around the factors x1, x0.5, x0.2 and x0.1. The selected factor is highlighted.

5.2.5 Integrate Current Trace

When button **5** is pressed, the display will show the integrated waveform of the selected trace. The voltage datum is taken as zero for integration and the cursor reads out the value in Vs - volt-seconds - or similar units.

5.3 Trace Arithmetic

Pressing button **6** on the Post Storage Master Menu selects the Trace Arithmetic Menu shown below in figure 5.3

```
<< TRACE ARITHMETIC MENU>>

[TR1] TR2 REF . . . . . 1

[ADD] SUBTRACT MULTIPLY . . . 2

TR1 [TR2] REF . . . . . 3

RESULT TO: TR1 TR2 [REF] . . . 4

SCALE: [x1] x0.5 x0.2 x0.1 . . . 5

EXECUTE . . . . . 7
```

Figure 5.3. Trace Arithmetic Menu

Using buttons **1**, **2** and **3** the traces involved and the calculation required can be chosen with the selected option being highlighted.

When multiply is selected the scale line next to button **5** appears so that a scale factor can be applied to the calculation result to allow it to fit on the screen

The arithmetic result will be stored in the trace selected with button **4**.

Pressing button **7** - Execute - causes the calculation to happen.

5.4 Persistence/Limits Testing

Button **7** on the Post Storage Master Menu selects the Persistence/Limits Testing Menu - figure 5.4.

```
<< PERSISTENCE/LIMITS TESTING>>

SET UPPER LIMIT . . . . . 1

SET LOWER LIMIT . . . . . 2
TEST LIMITS:
   Off On [Stop-on-fail] . . . . 3

DISPLAY LIMITS: Off [On] . . . 4

PERSISTENCE: [Off] Time Cycles . . 5
PERSISTENCE TIME (s):
   0.5 2.0 5.0 [15] 30 90 ∞ . . 6
PERSISTENCE CYCLES:
   10 [20] 50 100 200 500 ∞. . 7
```

Figure 5.4. Persistence/Limits Testing Menu

5.4.1 Limits

Captured traces can be compared against pre-defined limit traces providing a pass/fail indication.

To set the upper and lower limits select the required trace using the select trace button (31) and press either button **1** or **2** as required. Repeat for the other limit. When a limit has been successfully set, the message LIMIT SET is displayed.

Limit traces may be transferred between the DSO and an external computer, using the mnemonics STU for the upper limit and STL for the lower limit, using either the data transfer facility described in section 2.6 or the SCPI commands, depending on whether the GPIB option is fitted.

When display limits is on, the band between the upper and lower limits will be displayed.

Limit testing may be turned On or Off or set to Stop-on-fail by pressing button **3**. Limits testing will be performed on all the data points of both the upper and lower limit traces within the area bounded by the cursor and time datum lines. When turned On, each successive acquisition is tested and a warning message displayed when a trace is outside the limits. This warning and trace will be overwritten by the next acquisition.

If the limits mode is set to Stop-on-fail, acquisitions are halted when a trace that is outside the limits is captured, allowing it to be examined. This screen picture can be plotted, and with the internal color plotter, the upper and lower limits will be in the same color as the reference trace to distinguish them from the failed trace.

During limits testing the trigger level and position markers are not displayed.

Test Limits and Display Limits cannot be turned on if the DSO is in X-Y mode or if X-Mag is turned on. Similarly, X-Mag or X-Y mode cannot be selected if either Test Limits or Display Limits is on. If any of these situations occur one of the following messages will be displayed as appropriate.

NO LIMITS DISPLAY IN XY

NO XY WHEN LIMITS DISPLAYED

NO LIMITS DISPLAY IN X-MAG

NO LIMITS TESTING WITH X-MAG

NO X-MAG WHEN LIMITS DISPLAYED

NO X-MAG WITH LIMITS TESTING

Also, Display Limits cannot be turned on if persistence is on. Trying to select this mode results in the message;

NOT WHEN PERSISTENCE ON

A record of all failing traces can be automatically plotted by setting the limits testing mode to stop on fail, and selecting Auto Plot from the plotter menu. Any acquired trace that then falls outside the limits will be plotted. If the plot button is not pressed to initiate a continuous sequence, only the first failing trace will be acquired and plotted.

On the 100MHz instrument, the Limits fail line (pin 18) on the rear panel RS423 connector will go high if limits test fails.

5.4.2 Persistence

To obtain a persisted display, either the number of acquisitions accumulated before the display is cleared or the absolute time between display clearances can be set from the Persistence/Limits Menu.

The choice of Persistence for time or number of acquisitions is made using button **5** with the actual time or number of cycles set by button **6** or **7** as appropriate.

When using the persistence mode, the trigger level and position markers are not displayed.

If Display Limits is on, then persistence cannot be selected and the message NOT WHEN LIMITS DISPLAYED is shown if button **5** is pressed.

6.0 Battery Unit Operation

The battery unit option for the DSO provides the instrument with built–in Nickel Cadmium batteries and a fully automatic charger which allows uninterrupted operation of the DSO in the event of an AC supply failure and complete operation independent of an AC supply.

The batteries are fully protected against damage from over-charge or over-discharge and automatically receives a fast recharge followed by a continuous trickle charge when AC power is restored or re-applied to the unit.

A DSO with the battery option operates as an integral unit. All the normal functions of the DSO with the exception of line trigger are available and function as described elsewhere in this manual. Full operation of the DSO is also available while the batteries are recharging.

In the following text, battery unit refers to the option and DSO refers to the main oscilloscope. The circled numbers in this section refer to the numbered controls in figure 6.2

An AC supply is applied to the battery unit. This charges the batteries and is linked through the battery unit to power the DSO. The battery unit then also provides a DC supply to the DSO for use in the absence of an AC supply.

The battery unit is electrically connected to the DSO by two rear panel cables; one for the AC supply and one for the DC supply.

CAUTION: Before use ensure that the connections between the battery unit and the DSO are correct, see figure 6.0.

6.1 AC Supply Operation

To operate either the DSO or the battery unit the master on/off switch (64) on the front of the battery unit must be turned on.

If the instrument has been unused for a period of a month or more at 20°C or for a week or more at 50°C, individual cells within the batteries may have lost different amounts of charge. 24 hours operation on charge is required prior to discharge.

With an AC supply applied to the battery unit, and the master power switch (64) turned on, the batteries are on charge. See section 6.3.

When the DSO power is also switched on, the DSO operates from the AC supply. Normal operation of the oscilloscope is possible, and the batteries remain on charge.

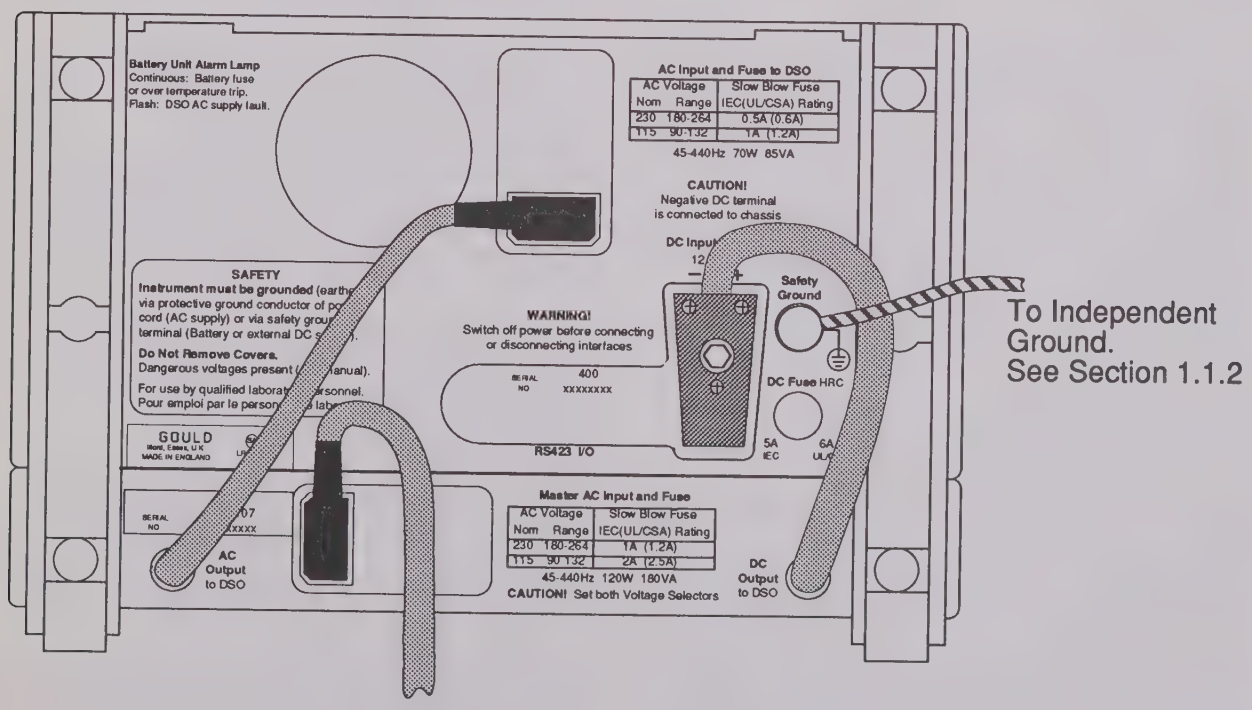


Figure 6 Battery Unit Interconnections

6.2 DSO Battery Operation

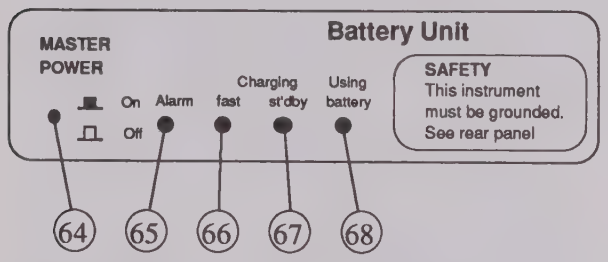


Figure 6.2 Battery Unit Front panel indicators

If no AC supply is available, the DSO can be powered from the battery unit simply by turning both the Master power switch (64) and the DSO power switch (63) on. If the DSO is in use on an AC supply that is interrupted, the operation of the DSO is uninterrupted as it changes to DC operation.

Whenever the batteries are supplying power to the DSO the Using battery lamp (68) is illuminated.

When the batteries approach full discharge their output is automatically cut off to prevent damage due to deep discharge. In this state no lamps on the battery unit will be illuminated.

Similarly, there will be no lamps illuminated if there is no AC supply and the DSO is switched off, whether or not the battery unit is switched on.

6.3 Battery Recharge

To recharge the batteries, the master on/off switch (64) on the front of the battery unit must be on and AC power supplied to the rear socket.

After any period of battery operation the battery unit will power up in fast charge mode when the AC supply is restored or re-applied. After a time period dependent on the discharge time, which allows at least 80% of the charge withdrawn to be replaced, the unit reverts to standby charge mode. This replenishes approximately 5% of the total battery capacity per hour, and is maintained continuously to hold the batteries in the fully charged state.

The batteries will be charged by the AC supply whether or not the DSO itself is turned on.

When AC is applied, either indicator (66) or indicator (67) will be illuminated to show the charge mode.

Indicator (66) shows that the battery is on fast charge, and indicator (67) shows that the battery is on standby charge.

No harm can be caused to the batteries by leaving them on standby charge for indefinite periods, although if they have been left in this mode for a long time, one cycle of full discharge and fast recharge may be required to obtain maximum capacity.

Limited battery capacity is available to operate the DSO if the AC supply is removed for any reason during fast charge. After full discharge, the battery capacity will be approximately half the elapsed recharge period.

If the unit is used outside the temperature range of +15°C to +35°C, the normal operation may be limited as discussed in section 6.5.

6.4 Alarm Conditions

The alarm lamp (65) will flash if the DSO attempts to draw power from the batteries while an AC supply is present. i.e. when the DSO should operate from the AC supply. This condition only occurs if the interconnecting AC cable is not connected or the DSO's AC supply fuse is open.

Once this condition is detected, the battery supply to the DSO is automatically switched off.

When the fault has been remedied, the alarm condition can be cleared by turning the master power switch (64) off for at least 10 seconds and then on again.

The alarm lamp (65) will be illuminated constantly if the battery temperature trip operates - see section 6.5 - or if a severe fault blows the internal battery protection fuse. Replacement of this fuse requires removal of the instrument covers and it should only be attempted by suitably qualified personnel. See section 1.1.3.

6.5 Extreme Temperature Operation and Storage

The DSO may be powered from the battery unit at any ambient temperature up to +45°C. However, the internal battery temperature detector may inhibit full fast charge at temperatures above 35°C. In this condition, both the standby charge lamp (67) and the alarm lamp (65) will be on constantly.

Charging is interrupted until the battery temperature reduces naturally to below the trip temperature, when the alarm lamp will be extinguished. Standby charge will then be resumed. At least 24 hours standby charge may then be required to regain full charge.

Although the battery unit may be stored at temperatures up to 50°C, and operated at temperatures up to 45°C, it is recommended that the period of such usage is limited. Prolonged exposure to high temperatures will adversely affect the battery life.

The battery unit may be used or recharged at temperatures down to 0°C but repeated recharge below 15°C may adversely affect the battery life.

The batteries will not be damaged by storage in the discharged state, however, it is recommended that they are fully charged before being unused for long periods. 24 hours operation on charge is recommended before use, after the unit has been unused for more than a month at 20°C, or a week at 50°C.

6.6 Independent Operation of DSO

In any circumstances if the battery facility is not required the AC supply link from the battery unit to the DSO can be disconnected and an AC supply fed directly into the DSO. In this mode, the master power switch (64) must be off or the DC cable disconnected from the DSO.

This mode of operation allows the use of the DSO on an AC supply above the 45°C limit for battery operation, but below the 50°C limit for the DSO alone.

Similarly, if the DC cable from the battery unit is removed from the DSO, an external DC supply can be used to power the DSO. For example, a high capacity battery could operate the DSO remote from an AC supply for long periods.

The batteries cannot be re-charged from an external DC supply.

7. Alphabetical Summary of Controls

AC/DC/Gnd (20) & (24) Controls the type of coupling between the instrument and the input signal. **AC** is used to remove DC components from signals of between 4Hz and the instrument bandwidth limit (20, 50 or 100MHz). **DC** couples the input signal directly to the instrument, so all frequency components of the signal up to the instrument limit will be displayed. **Gnd** internally disconnects the inputs from the instrument; a 0V reference signal is displayed instead.

Add (22) Displays the sum (or difference if one channel is inverted) of the channels. The original traces disappear and the resultant trace is displayed as a new Channel 2 trace.

Arm'd (54) Illuminates after **S/Shot** is pressed; it will stay lit until either the acquisition is complete or the **Run** button has been pressed.

AUTO SETUP (17) Will attempt to arrange the display so that two to five complete cycles appear, with the amplitude set so that the height of the trace is between two and five screen divisions. Also, it selects **Auto** trigger to ensure that the screen is frequently updated and a trace will be visible. If the frequency of the input signal is less than 20Hz, this function may not operate correctly.

Auto/Norm (26) Selects the trigger mode. **Norm** means that The instrument will only initiate captures when a valid trigger is received. **Auto** triggering is the same as **Norm** except that if no valid trigger has been received for some time, an artificial trigger will be generated: the instrument will generate its own triggers if no valid trigger has been received for 0.05s (i.e. 20Hz is the lower limit).

CH1/CH2/Ext/Line (29) Steps through trigger sources.

CH1 (X) (60) One of two channel signal input sockets, this one being for the connection of signals up to ±400V peak to Channel 1. It is used for the X component of an X-Y mode trace. It can also be a trigger source if selected using **CH1/CH2/Ext/Line.**

CH2 (Y) (59) As CH1, but CH2 is used for the Y component of an X-Y trace, where CH1 is the X component. It can also be a trigger source if selected using **CH1/CH2/Ext/Line.**

CURSOR (44) & (45) These two buttons control the movement of the cursor.

Control (9) Selects the control master menu.

Dat/Pos/Mag (30). **Dat:** Allows the **POST STORAGE/DATUM** keys to be used to control the movement of the datum lines. **Mag:** this allows the vertical magnitude of a stored waveform to be varied using the **POST STORAGE/DATUM** keys. **Pos:** this allows the trace on which the cursor is placed to be shifted using the **POST STORAGE/DATUM** keys.

EXT TRIG Socket (58) for the connection of external triggers of up to ±250V peak.

hf rej/AC/DC (28) Selects trigger coupling. The **hf rej** (high frequency reject) option is a 15kHz low-pass filter. Any coupling may be used with any trigger source.

Level (52) & (53) Adjusts the trigger level, which is indicated by two trigger bars on the display.

Mag (18) Used to control the horizontal magnification of the traces; when selected, a x10 expansion around the center of the screen is applied to the traces. The timebase display is altered to reflect the expansion.

Menu/Traces (0) Swaps the display between the last used menu and the trace display.

Mode (11) Selects one of three display modes. **Refreshed** mode is the normal oscilloscope mode whereby the trace is acquired from left to right. **Roll** mode is like a chart recorder: the display scrolls from right to left as the trace is acquired. **X-Y** mode takes the **CH1(X)** input as the X (horizontal) component and the **CH2(Y)** input as the Y (vertical) component.

Off/On/Inv (21) & (25) Switches the channel **On** or **Off.** If the channel is on, its trace can be displayed **Inverted.**

Plot (10) Produces a plot of the current display on a suitable plotter. If a plot is in progress, pressing this button will abort it.

Pos'n (46) to (49) These controls move the appropriate channel's trace vertically.

Position (34) & (35) Moves all traces horizontally.

Post Store (8) Selects the post storage master menu.

POWER (63) Used to switch the instrument on or off.

Pre-Trig/Delay (50) & (51) Used in conjunction with the menus to control the degree of pre-trigger% or trigger delay.

Run (13) Puts the instrument in continuous capture mode; the instrument automatically re-arms itself after each acquisition.

Select Trace (31) Places the cursor onto a displayed trace.

S/Shot (12) Arms the instrument for a single-shot triggered acquisition sweep (capture). The **Arm'd** light will be illuminated to show that this button has been pressed.

Stor'd (55) Illuminates on completion of a single-shot acquisition. It will stay lit until the instrument is re-armed or until **Run** is pressed.

TIME/DIV (32) & (33) Controls the sweep rate of the trace. The timebase can be varied from 50s/div to 0.1µs, 50ns or 25ns/div, depending on the instrument type, in a 1, 2, 5 sequence of values.

Trace Hold (14), (15) & (16) Freezes the relevant trace or traces until pressed again.

Trig'd (57) This lights up when the instrument is receiving valid triggers.

Uncal Controlled by the **Var** button. When lit, the coarse setting of the attenuator remains unchanged, but a variable gain is applied to the input signal. This control applies attenuation in the range of 1 to 0.4. Thus, with an initial setting of 1V, the actual sensitivity of the channel may be set anywhere between 1V and 2.5V per division. The **V/DIV** buttons are used to vary the sensitivity.

Var (19) & (23) Toggles between Uncal and Cal.

V/DIV (36) to (39) Adjusts the sensitivity of the instrument over discrete calibrated ranges from 2mV/div to 5V/div in 1, 2, 5 steps. With a x10 probe the ranges are 20mV/div to 50V/div at the probe tip. Input voltage must not exceed ±**400V** peak. If the **Uncal** light is on, then these buttons control the sensitivity over an uncalibrated continuous range of values.

+/– (27) Selects triggering on positive or negative slopes.

Appendix 1: Screen Messages

When something is wrong, an error message will be displayed in inverse text near the bottom of the display. Also in some cases a message appears to confirm that an action has occurred.

Brief explanations of when these messages occur are given below in alphabetical order.

GPIB and RS423 messages are not shown in this list, see the separate list in the remote command section.

1. CALIBRATION DISABLED
   If calibrate current setup is pressed while Autocal is disabled.
2. GPIB MUST BE ADDRESSABLE
   If remote channel GPIB is selected while the mode is set to talk only.
3. GPIB MUST NOT BE ADDRESSABLE
   If GPIB is selected as the plot destination while set to addressable.
4. GPIB REMOTE:- PRESS PLOT TO ABORT
   Appears when the instrument has been driven remote by the GPIB interface.
5. LEVEL FIXED WHEN SOURCE = LINE
   If the trigger level controls are touched when line trigger is selected.
6. MUST BE ADDRESSABLE WHEN REMOTE
   If GPIB talk only is selected while the remote channel is set to be GPIB.
7. NO ADD IN XY MODE
   If trying to select ADD when in X-Y mode.
8. NO ADD WHEN HELD
   If the add button is pressed when either or both CH1 or CH2 are held.
9. NO BINARY WITH X-ON X-OFF
   If X-ON X-OFF is selected and binary number base is also selected.
10. NO CURSORS IN XY
    If either the Datum or Cursor position keys or the select trace button is pressed in X-Y mode.
11. NO HORIZONTAL MAG
    If post storage horizontal magnification is attempted.
12. NO LIMITS DISPLAY IN XY
    If limit display is turned on while the instrument is in XY mode.
13. NO LIMITS DISPLAY IN X-MAG
    If limit display is turned on while the instrument is in X-MAG mode.
14. NO LIMITS TESTING ON REF TRACE
    If limit testing is turned on while the cursor is on the reference trace.
15. NO LIMITS TESTING WITH X-MAG
    If limit testing is turned on while the cursor is in X-MAG mode.
16. NO POST STORAGE IN XY
    If the cursor is selected and then the unit is switched to X-Y mode and then a post storage key is pressed.
17. NO TRACE SELECTED
    If the cursor is off and either the restore, cursor position or post storage movement keys are pressed.
18. NO X-MAG IN ACTIVE ROLL
    a) If the X-MAG key is pressed while the instrument is in ROLL mode on timebase ranges slower than 20ms/div with the traces not stored and neither channel held.
    b) If in ROLL mode on timebase ranges faster than 50ms/div with continuous acquisitions and X-MAG on, and then the timebase range is changed to be 50ms/div or slower.
19. NO X-MAG IN XY MODE
    If X-MAG is pressed when in X-Y mode.
20. NO X-MAG WHEN LIMITS DISPLAYED
    If X-MAG is pressed while display limits is on.
21. NO X-MAG WITH LIMITS TESTING
    If X-MAG is pressed while the instrument is in limits testing mode.
22. NO XY WHEN LIMITS DISPLAYED
    If XY is pressed while display limits is on.
23. NO XY WHEN CHANNELS ADDED
    If trying to select X-Y mode when channel ADD is on.
24. NO XY WITH X-MAG
    If trying to select X-Y mode when X-MAG is on.
25. NOT WHEN LIMITS DISPLAYED
    If persistence is turned on while display limits is on.

26. NOT WHEN PERSISTENCE ON
    If display limits is turned on while the instrument is in persistence mode.

27. PLOT OUTPUT MUST NOT BE GPIB
    If addressable GPIB mode is selected while the plot destination is set to GPIB.

28. PLOTTING - PRESS PLOT TO ABORT
    Appears whilst plot is in progress.

29. RS423 REMOTE:- PRESS PLOT TO ABORT
    Appears when the instrument has been driven remote by the RS423 interface.

30. TR1 CURSOR MEASUREMENTS OFF
    If all three cursor measurement options are set to off, this message appears.

31. TR1 INVALID DATA
    If the data is invalid for the measurement selected.

32. TRACE COPIED
    To confirm that a trace has been copied to the reference trace.

    (Note also that if a trace is copied to the reference trace, the reference trace is automatically turned on as well).

33. TRACE MEMORY UNUSED
    a) If trying to turn the reference trace on when it has not been previously copied/saved.

    b) If an attempt is made to recall a backup memory when that memory has not been previously saved.

34. TRACE NOT YET STORED
    If the cursor is selected and a post-storage key pressed but the trace is not stored or held.

35. TRACE RECALLED
    To confirm that a trace has been recalled.

36. TRACE SAVED
    To confirm that a trace has been saved.

37. USE CH1 POS'N KEYS IN XY
    If either horizontal position key is pressed when in X-Y mode.

38. WAITING FOR TRIGGER
    If S/SHOT has been selected but no trigger has been detected within 2s.

39. X-MAG RESTORED WHEN STORED/HELD
    If the traces are stored or held in ROLL mode. Then if X-MAG is selected and either S/SHOT or RUN is pressed, or either channel unheld.

    i.e. X-MAG has been turned off while the display is in active roll mode, but it will be restored when the display is once again stored or held.

40. 0.1µs TO 100µs/DIV, NO MAX-MIN
    If max/min is selected when timebase is faster than 100µs/DIV.

    Note that this message is for a 20MHz instrument. For a 50MHz instrument, the minimum time is 50ns not 0.1µs and for a 100MHz instrument it is 25ns.

Appendix 2: Specification

DISPLAY

CRT: 5 inch diagonal screen. Raster scan, vertically scanned.

Graticule: Electronically generated 8 x 10 divisions with 0.2 sub divisions.

Intensity: Separate controls for Traces, Graticule and Alphanumerics.

VERTICAL SYSTEM

Two identical channels, CH1 and CH2. Inputs via BNC connectors.

Sensitivity: 2mV/div to 5V/div in 1-2-5 sequence.

Accuracy: ±2.5% of reading ±1 digitizing level (1/30 of a division).

Variable Sensitivity: >2.5:1 range allowing continuous adjustment of sensitivity between ranges.

Input Impedance: 1M Ω/28pF.
465 1MΩ/20pF

Input Coupling: DC-GND-AC.

Bandwidth:

400 and 420: DC: 0 - 20MHz (-3dB)
AC: 4Hz - 20MHz (-3dB)
450: DC: 0 - 50MHz (-3dB)
AC: 4Hz - 50MHz (-3dB)
465: DC: 0 - 100MHz (-3dB)
AC: 4Hz - 100MHz (-3dB)

Input protection: 400V DC or peak AC. (10kHz or less on all ranges below 0.2V/div.)

Expansion: Post storage x 0.062 to x 4.00.

HORIZONTAL SYSTEM (Timebase)

Sweep rate:

400 and 420: 27 ranges in 1-2-5 sequence
450: 28 ranges in 1-2-5 sequence
465: 29 ranges in 1-2-5 sequence

Transient capture:

400 420 & 450: 500ns/div to 50s/div
465: 250ns/div to 50s/div

Repetitive sampling:
400 and 420: 200 and 100ns/div
450: 200, 100 and 50ns/div
465: 100, 50 and 25ns/div

Sample rate accuracy: ±0.01% of sample time.

Expansion: x 10 with linear dot interpolation.

TRIGGER DELAY

Trigger delay range: 20ns to 5000s.

Trigger delay accuracy: ±0.01%, ±1ns.

Pre-trigger: 0 to 98% of sweep in 0.4% steps.

Resolution: 2% of time/div, 20ns min.

TRIGGER SYSTEM

Variable level control with Auto/Normal facility, resolution of less than 0.1 div.

Auto/Normal Mode: In Auto the timebase free runs when insufficient signal (20Hz-20, 50 or 100MHz) is present or when the selected level is outside the range of the input signal.

Source: CH1, CH2, External or Line.

Coupling: DC, AC, high frequency reject filter.

Slope: +ve or -ve.

Sensitivity 400/420:

Internal	DC Coupled	<0.3 div DC to 2MHz.
		<1.5 div 2MHz to 20MHz.
	AC Coupled	<0.3 div 10Hz to 2MHz.
		<1.5 div 4Hz to 20MHz.
External	DC Coupled	<150mV DC to 2MHz.
		<600mV 2MHz to 20MHz.
	AC Coupled	<150mV 10Hz to 2MHz.
		<600mV 4Hz to 20MHz.

Sensitivity 450:

Internal	DC Coupled	<0.3 div DC to 5MHz
		<1.5 div 5MHz to 50MHz
	AC Coupled	<0.3 div 10Hz to 5MHz
		<1.5 div 4Hz to 50MHz
External	DC Coupled	<150mV DC to 5MHz
		<600mV 5MHz to 50MHz
	AC Coupled	<150mV 10Hz to 5MHz
		<600mV 4Hz to 50MHz

A2

Sensitivity 465:

Internal	DC Coupled	<0.3 div DC to 10MHz
		<1.5 div 10MHz to 100MHz
	AC Coupled	<0.3 div 10Hz to 10MHz
		<1.5 div 4Hz to 100MHz
External	DC Coupled	<150mV DC to 10MHz
		<600mV 10MHz to 100MHz
	AC Coupled	<150mV 10Hz to 10MHz
		<600mV 4Hz to 100MHz

Range: Internal ±10 divisions.
External ±3V.

External input impedance: 100kΩ/10pF.

External input protection: 250V DC or peak AC.

Trigger jitter, non ETS ranges: (50s/Div to 500ns/Div), ±2% of time/Div (unexpanded), ± 2ns.

Trigger Jitter, ETS Ranges:
400 & 420: ±2ns.
450: ±1ns.
465: ±0.5ns.

DISPLAY MODES

Refreshed: Stored data and display updated by triggered sweep.

Roll: Stored data and display updated continuously for timebases 50ms/div to 50sec/div. Trigger stops the updating process.

Refresh and roll operate as repetitive single shot for timebase ranges faster than 50ms/div.

Dot join: Dots are joined by vertical raster lines. Linear dot interpolation is provided when the trace is horizontally magnified (using Mag).

X-Y: X-Y display is 8 x 8 divisions. Stored data and display are updated by triggered sweep. There is no dot joining, x 10 expansion or cursor in this mode. CH1 is used as the X (8 bit resolution 25 steps/div) and CH2 as the Y (7 bit resolution 15 levels/div) deflection.

Single trace: CH1 or CH2.

Dual trace: CH1 and CH2.

Add: CH1 and CH2 can be added to give the algebraic sum of the two channels. Addition is pre-storage.

Invert: Both channels may be independently inverted.

Single Shot: Freezes store at the end of a single triggered sweep.

Display trace hold: (all) Freezes the display immediately.

Channel 1 Trace hold: Freezes channel 1 display immediately.

Channel 2 Trace hold: Freezes channel 2 display immediately.

Reference trace: One reference trace can be displayed in addition to the two input channels. This can display a waveform memory of a trace copied from CH1 or CH2.

ACQUISITION SYSTEM

Maximum sample rate

400, 420, 450: 100 megasamples/sec simultaneously on each channel.

465: 200 megasamples/sec simultaneously on each channel.

Vertical resolution: 8 Bits (1 in 256) 30 levels per division.

Record Length: 501 points per channel.

ACQUISITION MODES

Normal mode: Transient and repetitive signal capture. (Repetitive capture is only on timebase ranges faster than 200ns/div. This gives an equivalent sample rate of 2ns/sample on the 100ns/div range).

X-Y Mode: Bandwidth 20, 50 or 100MHz (-3dB) depending on instrument type. Phase difference <3° at 1/200 of the bandwidth. Acquisition rate dependent on the timebase range.

Averaging: Averages can be set from 2 to 256 in binary sequence, selected from the menu system. Averaging operates continuously or, using single shot for the set number of acquisitions, (weighted average).

Peak detection: Minimum pulse width 1µs. 100% probability of capture. Operates on timebase range 100µs/div or slower.

MEMORY

Waveform memory: 2 reference memories are selectable for waveform data storage. These memories are Non-volatile.

A2

Set-Up: The control set-up is retained in memory during power down.

Retention time: The memory support is trickle charged and will retain information for 1 month after power down.

ON SCREEN MEASUREMENTS and ALPHANUMERIC DISPLAY

Datum Lines: Horizontal and vertical full screen amplitude time and voltage datums.

Cursor: The measurement cursor can be assigned to a trace and measurements made in time and voltage with respect to the datums.

Cursor measurement display: Δ Voltage and Δ Time displayed on screen.

Accuracy: Voltage ± 2.5% of reading, ± 1 digitizing level (1/30 of a division).
Time ± 0.01% of reading ±1 digit.

Resolution: Voltage 0.4% of F.S.D.
Time 0.2% of F.S.D.

Trigger Indication: On screen trigger level and trigger point indication.

Alphanumerics: Display on screen to indicate vertical sensitivity and input coupling for each channel, timebase speed and pre-trigger or trigger delay. Arrow for off screen indication of trigger point and traces.

A2

MENU SELECTION

Control master menu: Selects menus for prime functions:- Status, display and trigger facilities, display intensity, reference trace control, I/O interfaces, and special functions.

Menu/traces: Alternately switches between trace display and last menu selection.

Post storage master menu: Selects menus for fast access to save/recall trace, plot output parameters and waveform processing functions.

AUTO SET UP

Automatically sets the front panel controls to display any applied repetitive input signal for frequencies greater than 20Hz.

RS423 PLOTTER INTERFACE

Serial interface port for bi-directional waveform data and associated range parameter transfer.

Baud rate: 75, 150, 300, 600, 1200, 2400, 4800, 9600.

Data bits: 8.

Parity: None.

Start-stop: Fixed: one start, one stop bit.

IEEE-488 Interface

Parallel data interface which permits full remote control of the instrument

Address: menu selectable 00 to 30

Internal Color Plotter

Paper type: Gould part No. 04101165 (10 roll pack).

Paper length: 45 meters, equivalent to approximately 250 plots.

Pen type: Gould part No. 04101175 (4 color pack).

Pen life: Minimum of 250 meters line length, approximately 175 plots.

DIGITAL PLOTTER OUTPUT

The instrument can directly output to suitable HPGL format plotters via the RS423 interface port (or GPIB if fitted).

Plot mode: Manual or auto selection to output a stored trace.

Annotation: Range and scaling annotation, graticule cursors and cursor readout can all be included in the plot output.

WAVEFORM PROCESSING FUNCTIONS

Cursor Measurements

Voltage and Time

The cursor measures the voltage and time relative to the voltage and time datum lines respectively.

Peak-Peak

Calculates peak-to-peak voltage of the waveform bracketed between the time datum and cursor.

Max-Min

Displays maximum and minimum voltage excursions of a waveform relative to the voltage datum position. The cursor and datum bracket the waveform of interest.

Risetime (falltime)

Calculates the rise or fall time between the 10% and 90% or customer defined percentage points of a signal; The cursor and datum bracket the waveform of interest and the 0% and 100% points are automatically detected by the instrument.

Overshoot (preshoot)

Calculates the over or pre shoot of a signal as a percent of the 100% point; The cursor and datum bracket the waveform of interest and the 0% and 100% points are automatically detected by the instrument.

Pulse Width

Calculates the time between 50% or customer defined percentage points of a pulse, with the pulse being bracketed between the time datum and the cursor.

Frequency, Period, Duty Cycle

Calculates the average frequency, period and duty cycle of a waveform. Uses either the voltage datum as the zero crossing point or the mean of the waveform. The cursor and time datum set the limits of the area of interest.

RMS

Calculates the root mean square (RMS) voltage of a waveform bracketed between the cursor and time datum. The voltages are calculated with respect to both the voltage datum (DC-RMS) and the mean of the waveform (AC-RMS).

Area

Calculates the area under a waveform bracketed between the cursor and the voltage and time datum lines.

Trace Manipulation

Filter

6 selectable stages of low pass filter for each timebase range.

Invert

Inverts the trace about the voltage datum.

Integrate

Calculates the definite integral and displays the resultant waveform. A scaling factor of x 1, x 0.5, x 0.2 or x 0.1 can be applied to the integrated waveform.

Trace Arithmetic

Add

Adds any two traces and displays the result in a selected trace.

Subtract

Subtracts any two traces and displays the result in a selected trace.

Multiply

Multiplies any two traces and displays the result in a selected trace. A scaling factor of x 1, x 0.5, x 0.2 or x 0.1 can be applied to the multiplied waveform.

Limits testing

Tests a waveform with respect to two definable limit waveforms and will display a TEST FAILED message if the acquired signal fall outside the limits. Acquisition can be continuous or stop-on-fail.

Persistence

Either the time, or number of acquisitions between screen clearances can be set to give a persisted trace display. Times of 0.5, 2.5, 5, 15, 30 or 90 seconds or multiple acquisitions of 10, 20, 50, 100, 200 or 500 traces can be selected. Both options can be set to infinity to give a permanent persistence display.

REAL TIME CLOCK (not on 400)

24 hour time and date set via a menu. Printed out on plots to give a permanent record of acquisition time. The time and date is maintained for approximately ten years with the instrument's power disconnected.

BATTERY UNIT 400-107

Operation of DSO from fully charged battery: 1.5 hours minimum

90% recharge time from full discharge: 5 hours maximum.

Battery life to 70% capacity:
200 complete discharge cycles at 20°C.

1000 50% discharge cycles at 20°C.

AC supply range: 90 to 130V or 180 to 265V, 45 to 400Hz.

Indication provided for:
Battery in use (discharging)
Battery on fast charge
Battery on standby charge
Alarm conditions

ENVIRONMENTAL

Temperature: Full specification: +15°C to +35°C.
Operating: 0°C to +50°C.
(0°C to +45°C with battery unit).
Storage: -40°C to +70°C.
(-40°C to +50°C with battery unit).

Humidity: Operating IEC68-2-Ca at 45°C with 95% RH. Non-operating IEC68-2-Db cycling 25°C to 45°C with 95% RH, 6 cycles (144 hours).

Vibration: MIL spec 810D. Random frequency vibrations of 5-500Hz at 1 g rms for 15 minutes.
IEC68-2-6 Test Fc. 15 cycles of 1 minute duration 10 to 55Hz at 0.6mm peak to peak displacement in each of the three major axis (4g at 55Hz).

Safety: Designed for IEC348 Cat 1 standard.

EMC: EMI to BS6527, VDE 0871 Class A.

ESD 10kV to IEC 801-2, BS6667-2.

MISCELLANEOUS

Calibrator: 1V peak to peak ±1%, frequency approx 1kHz calibration signal on front panel.

Ground: Front panel ground reference.

A2

POWER REQUIREMENTS

AC Voltage: 90 to 130V or 190 to 265V.

Frequency: 45 to 440Hz.

DC Voltage: 12 to 33V.

Power: 85VA/75W approx. (100VA with battery unit)

WEIGHT

400: 5.5kg (12lb) approx.

420, 450 & 465: 6.5kg (14.2lb) approx.

400 with battery unit: 11.7kg (25.7lb) approx.

400, 450 & 465 with battery unit: 12.7kg (27.9lb) approx.

DIMENSIONS

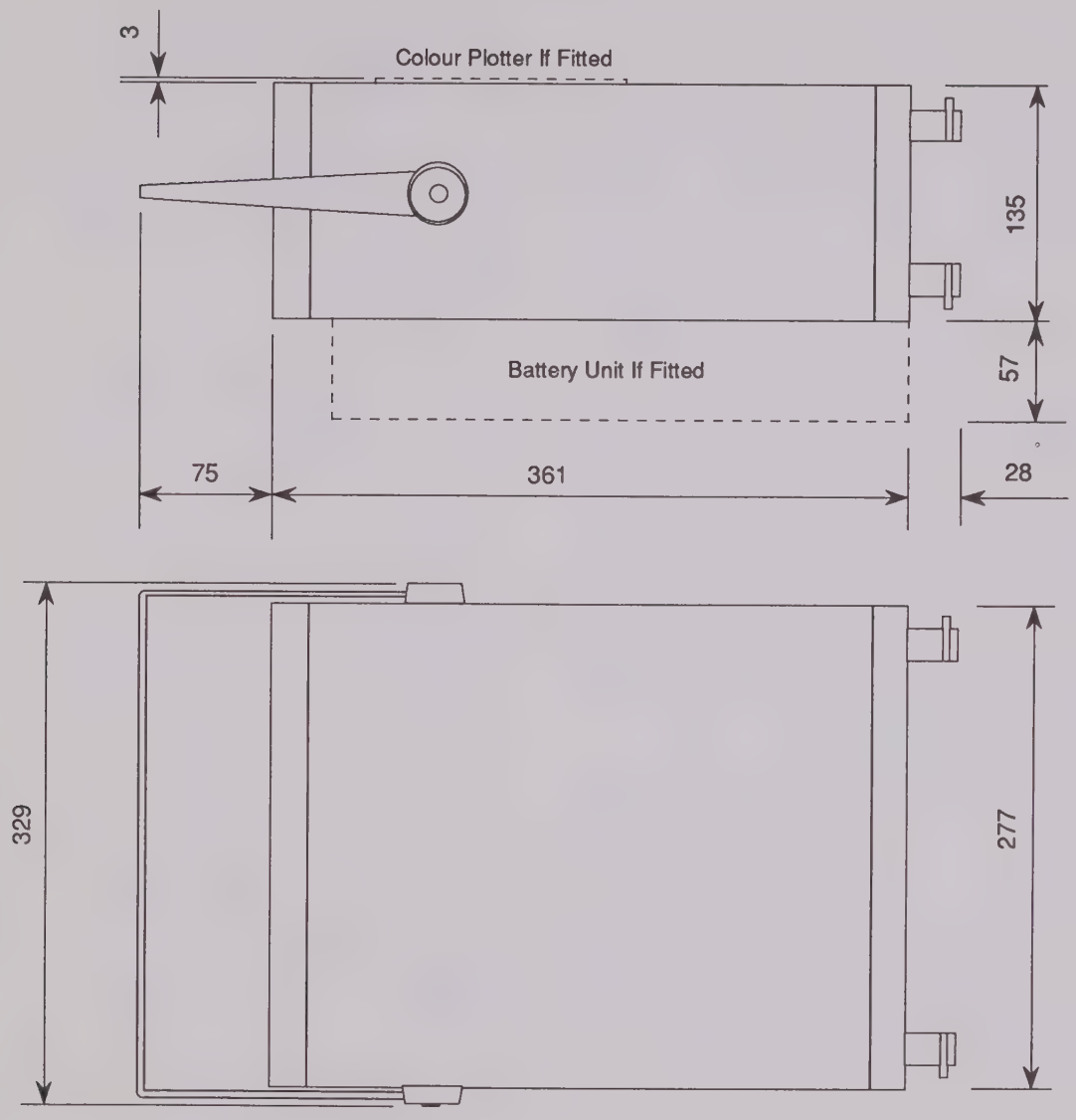
See Figure A2.

ACCESSORIES SUPPLIED

Operating Manual
Line Cord
DC Power Connector

OPTIONAL ACCESSORIES

Rack Mounting Kit	PN04090490
Carrying Case (soft padded)	PN04101221
Carrying Case (hard, foam lined)	PN04101222
Front Facia Cover	PN04101220
Accessory Pouch	PN04101223
Service Manual	PN04101224
Probe DC to 100MHz switched x1 and x10	PB12
Probe DC to 250MHz 1200V x100	PB17
Probe DC to 7MHz 15kV x1000	PB27
External TV Trigger Unit	PN04101245


3
Colour Plotter If Fitted
135
Battery Unit If Fitted
57
75
361
28
329
277

Appendix 3

Remote DC Operation of the DSOs

As well as the possibility of having an internal battery unit, the DSOs can be operated from external DC voltages between 12 and 33V measured at the DSO. This has the advantage of uninteruptable operation which an oscilloscope powered from an invertor type of DC supply does not have. Invertor type DC supplies are powered by batteries and generate AC power in the absence of an incoming AC supply. In order for them to start working they first have to detect the loss of the AC supply which can take a few seconds.

Any applications which require continuous operation of a DSO regardless of AC supply fluctuations or drop-outs, as well as those requiring a remote power source will benefit from the versatility of the DSO's DC power feature. Some examples of these applications are uninterruptable power supply development and troubleshooting, and troubleshooting of supply interference caused by large electric machines.

The DC operation power dissipation of the instrument varies from about 60 to 64W depending on instrument type and increases by about 5W when printing. This dissipation is a constant power load to the source.

This means that less current is drawn at higher voltages and conversely more current at lower voltages. The user should ensure that there is sufficient source voltage to overcome cable and connector voltage losses that may occur because of the relatively high current involved. See table A3.1

Figure A3.2 below shows the DSO's internal arrangement of the power connections. It can be seen that current will be drawn from the AC supply as long as the external DC input voltage is lower than the AC input voltage minus the two diode voltage drops in the bridge rectifier.

This simple diode ORing of the two power sources means that switching from one source to another is very quick - there is no interruption in the operation of the instrument while one source takes over from the other.

The diode in series with the external DC source protects the instrument against reverse polarity voltages and allows both the AC and DC supplies to be connected at the same with the source supplying the higher voltage being the one from which current is drawn.

Table of Annealed Copper wire sizes vs. length for 0.5V drop at 5 Amp current

Diameter (mm)	Cross Sectional Area (mm)	Length M
0.8	0.5	2.9
0.98	0.75	4.35
1.26	1.25	7.25
1.78	2.5	14.5
2.26	4.0	23.2
2.76	6.0	34.8
3.19	8.0	46.4
3.57	10.0	58.0

Table A3.1

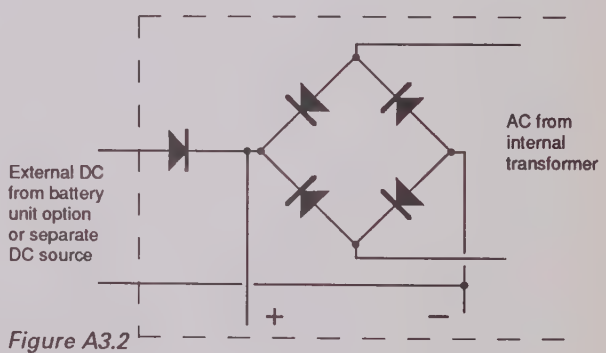
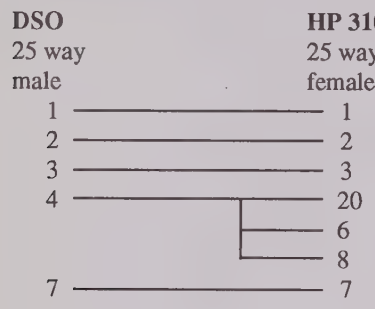


Figure A3.2

APPENDIX 4

Interfacing the DSO to a HP310 computer via the RS423 Port

When interfacing the DSO to a HP 310 via the RS423 port, the cable should be wired as follows:



To test the interface and connections, connect the above cable to the DSO and port 9 on the HP310, turn ON Channel 1 and Hold all and use the I/O Interface Menu to set the DSO operating conditions to be:

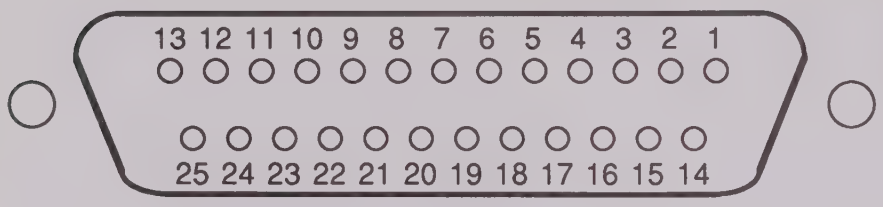
SPEED	2400
HANDSHAKE	CTS-RTS
NUMBER BASE	BIN

Now run the following short HP BASIC program:

```
10    DIM T$[4],C$[1050],D$[1050]
20    Bd=2400
30    CONTROL 9,3;Bd
40    ASSIGN @Scope_ad to 9
50    T$="ST1"
60    OUTPUT @Scope_ad USING "K";T$
70    ENTER @Scope_ad USING "#,523A";C$
80    D$=C$[19,521]
90    END
```

This sets up the HP 310 interface 9 to 2400 baud, requests trace 1 data, puts the response from the DSO, into string C$ and finally strips off the header information and puts only the actual data points into string D$.

This program is only intended as a guide to using the data transfer facility. Other languages or versions of BASIC may require different commands and different host computers may need different cable assemblies.



Pin	Signal	Description
1	0V	Protective Ground
2	RXD	Receive Data
3	TXD	Transmit Data
4	CTS	Clear to Send
5	RTS	Request to Send
7	0V	Signal Ground
9	0V	Ground
18	0V/5V	Test Limits Fail

Figure A5a RS423 Connector Pinout

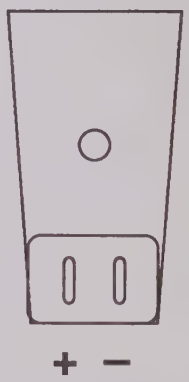
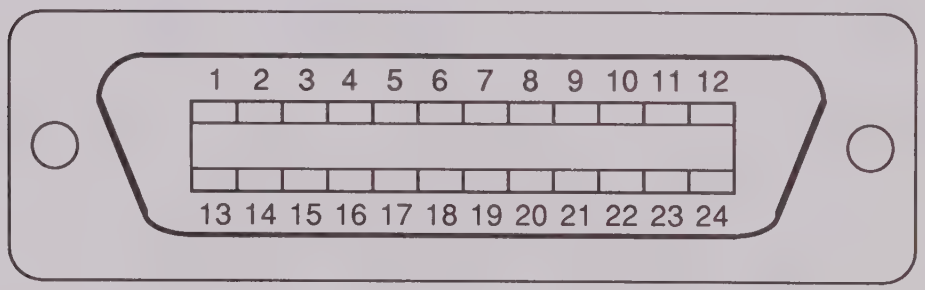


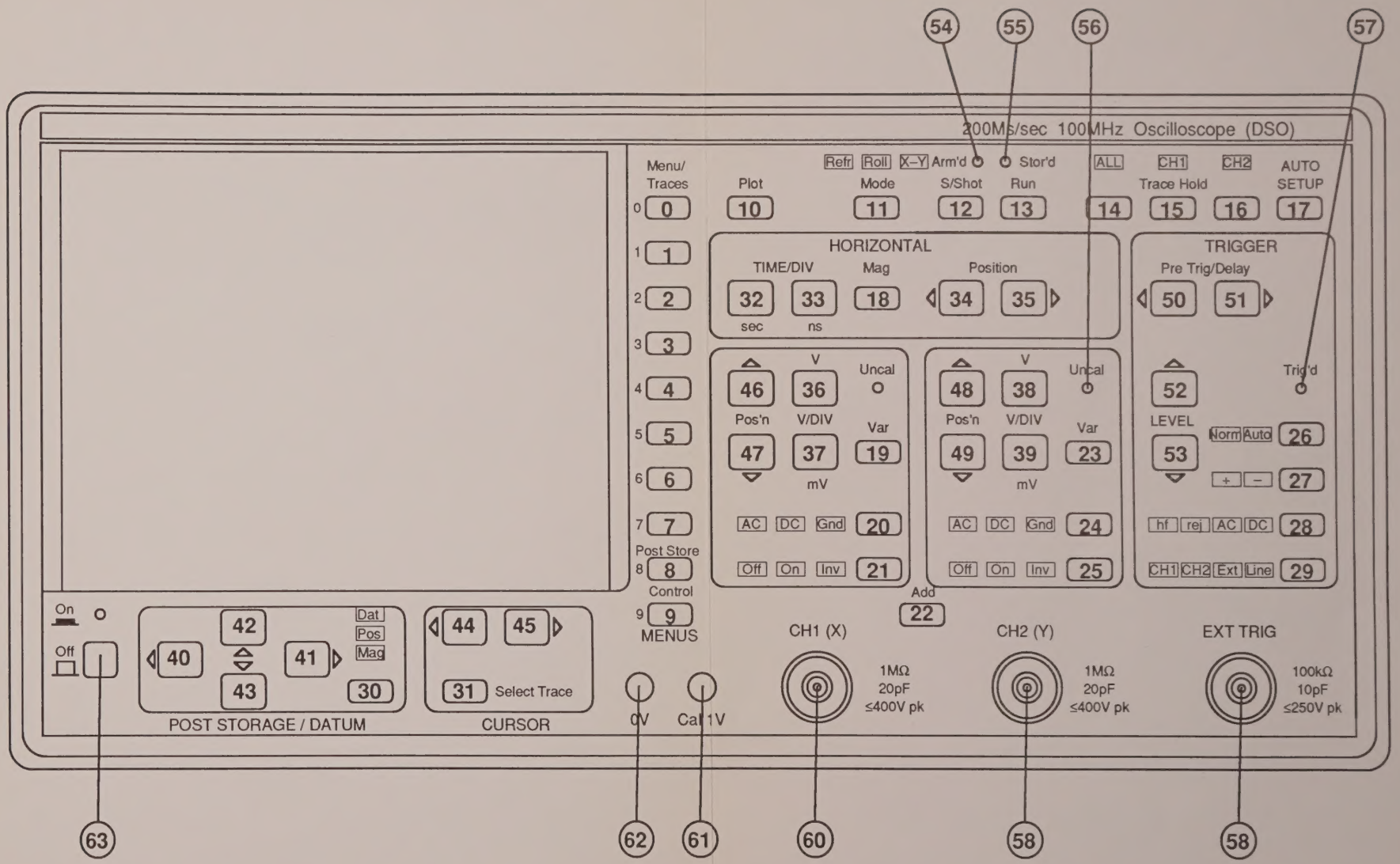
Figure A5c DC Connector Pinout



Pin	Signal	Description	Pin	Signal	Description
1	DIO1	Data input output line 1	13	DIO5	Data input output line 5
2	DIO2	Data input output line 2	14	DIO6	Data input output line 6
3	DIO3	Data input output line 3	15	DIO7	Data input output line 7
4	DIO4	Data input output line 4	16	DIO8	Data input output line 8
5	EOI	End Or Identify	17	REN	Remote Enable
6	DAV	Data Valid	18	(DAV)	Return line
7	NRFD	Not ready for data	19	(NRFD)	Return line
8	NDAC	Data not accepted	20	(NDAC)	Return line
9	IFC	Interface Clear	21	(IFC)	Return line
10	SRQ	Service Request	22	(SRQ)	Return line
11	ATN	Attention	23	(ATN)	Return line
12	Shield		24	Logic Ground	

Figure A5b GPIB (IEEE–488) connector pinout

Figure A5b GPIB Connector Pinout



N.B. Numbers in bubbles are not SYST: KEY numbers

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